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Refer: Silicon Chip Magazine December 2011

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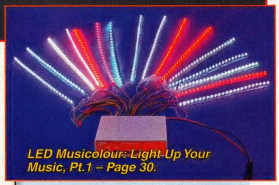

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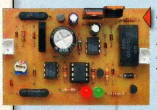

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Publisher's Letter

The attractions of electric cars

Following our review of the Nissan Leaf electric car in our August issue, we have had a number of emails which have generally contradicted our favourable impressions. The criticisms have been that the vehicle is too expensive, the range is nowhere near enough, the battery won't last and the overall economics or running it don't add up. Overall, that's a pretty deflating summary which has been echoed by some of the local newspaper reviewers.

Well, I have to say that these people just don't "get it". I would love one. I am a prime candidate for such a vehicle. I have a short run to work every day and a range of about 100km would easily satisfy most of my motoring. Sure there are times when I drive much longer distances but my wife and I have two cars between us; we'd keep a petrol vehicle for those occasions.

I also love the idea of having a very quiet car. I already have a quiet car in the form of an 8-year old Honda Accord. If I purchased another, I would likely buy the latest Accord with active noise cancellation for an even quieter drive. If I purchased an electric car, it would be quiet anyway. Apparently, overseas some electric and hybrid cars are now being fitted with a sound source to warn pedestrians and blind people because the vehicles don't make enough noise. Well blow that; I want my car to be utterly quiet!

I also like the idea of not making any noise when starting. Petrol and diesel cars can very noisy when they are starting, some needlessly so. For example, our Toyota Avalon revs the engine over 2000 RPM at start-up. This is part of the engine management system, apparently to quickly recharge the battery. In an electric, you just press the accelerator and move off; no noise.

Another great aspect of an electric car is that you never have to put petrol in the tank. My overall petrol use in my present car is not great and I probably only fill it up about 35 times a year (I drive less than 12,000km per annum). Still, I hate the whole ritual, especially if the petrol price is higher for that particular day.

I also get my car serviced twice a year and I hate that too, since it seems so expensive and is all involved with engine maintenance. That's not necessary with an electric.

So I do feel that electric vehicles have significant attractions for anyone who does not have to drive long distances every day and that includes many, if not most, car owners.

So what's stopping me from buying a Nissan Leaf right now? Well, I would like one but I don't need one. My present car could still last for quite a few years before I need to change it. As well, I am too stingy and I do agree that all electric cars are presently far too expensive and compare badly in a "whole of life total cost" with the latest petrol or diesel cars.

Eventually though, electric cars should get a lot cheaper and then they should sell in significant numbers. By that time, doubts about battery longevity or the high cost of replacement will probably have been addressed.

Still, it is likely that electrics will probably never better the most economical petrol or diesel cars in terms of actual energy use. That is because the batteries in electric cars are very heavy and there are significant losses when they are being charged and discharged. Sure, if they are charged at off-peak rates there will be a big saving in energy cost to the driver but I have to wonder how long that advantage will be available.

Why? Because governments extract a significant amount of tax from petrol and other fuels. They are unlikely to want to see that all disappear if lots of people buy electrics. Mark my word, they will figure out some way to charge more for the electricity used in charging electric car batteries.

Leo Simpson

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NATIONAL INSTRUMENTS

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Science teaching has not advanced

How right you were in your Publisher's Letter in the August issue of SILICON CHIP! I can clearly see the difference between being taught science in today's education system and the way I was taught in Europe in the 1960s. With science and technology racing forward, you would think that the subjects would be way ahead of what us older blokes were taught but not so. I found this out recently when I assisted a younger student at a friend's house with "science".

This involved a very basic circuit with a battery, a globe and a switch. The young student could not see what use this was and in the end I explained that this was the circuit of a pocket torch. The science subjects were seen as a waste of time and a nuisance. Then came the maths and trigonometry; another useless subject. "Why do we have to learn this rubbish? We'll never use it again." In the end, I managed to explain the Pythagorean Theorem but wasn't so lucky with equations.

Growing up in Europe in the 50s and 60s, I developed an interest in electronics and even today I am still building valve amplifiers for guitar players. With a seemingly inexhaustible junk box, transformers are no problem and neither are valves. With a multimeter and pen and paper, you soon know what will work and what will not. Am I supporting a dying art form? Will there be Australian-educated kids amongst the world's scientists of the future in this field?

I am well aware that electronics manufacturing in Australia has been on a downward slope. We don't build TV sets or radios anywhere I can think of; times and trends are changing. So it seems to me that there are no careers for young people in that field.

Does this mean that our kids are now taught the "legal minimum" of science by the subject being lightly brushed over, with understanding it as an option? I sincerely hope I'm wrong and a reader might be out there to fire up my optimism. However, I can foresee a generation coming up that will be one of button-pushers, unable to read the circuit diagram of an extension lead or worse, make one.

W. Schaaij,
Broken Hill, NSW.

Comment on Serviceman story

I have belatedly read "Serviceman's Log" in the June 2012 issue and would like to add a comment in relation to the "The Faulty Voltage/Current Calibrator". A. L. (the contributor of that article) mentions a Jaycar DMM that he checked against his "new" calibrator, and found some erroneous readings that he corrected by adjusting one of the trimpots.

The difference of 1.2V displayed between the calibrator's set voltage (3V) and the DMM's displayed voltage (4.2V) is quite a significant difference and way beyond what I would expect would be the tolerances of most of the components used in the construction of the DMM. However, I think I might have a viable theory behind the reason for the anomaly. I can't help thinking the main cause of this significant difference might be due to the trimpot itself being faulty.

I suspect that either the carbon track (assuming the trimpot is a standard open or "skeleton" type) has changed its resistance (as these are probably not precision pots to begin with) or that the adjustment mechanism is probably silver-plated and has oxidised (like silver does) and is preventing proper contact with the carbon track of the pot.

I suspect that a spray of contact cleaner might be a long-term fix. I have

Encouraging news on teaching science

With regard to the Publisher's Letter on the topic of the new Queensland science curriculum (August 2012), it's not all doom and gloom regarding Australians and science. There are some glimmers of hope across the border here in Queensland regarding science and the school syllabus. My daughter attends Loreto College at Coorparoo in Brisbane which is an all-girls school. You will be heartened to note that the science teacher she had last year got her really interested in science.

This is a significant achievement to get girls interested in science. He achieved the impossible where my daughter was actually doing her science homework first and actually reading the text book. This guy had the "knack". I had the opportunity to experience his class-room teaching when parents were allowed to spend a day at school with their daughters. I turned up without telling my daughter who thought I had declined the offer to attend.

It was definitely worth a year's school fees to see the look of "shock horror" on her face when I arrived at one of her classes. Anyhow the last lesson for the day was science. That's a tough gig for teachers to start with but the science teacher, who was a man in his senior years, delivered the best school-room science lesson I have experienced. Regardless of the capers the girls got up to, he managed to calmly roll it all into the lesson and get the girls thinking and talking about the experiment. They also had a lot fun and learnt a lot.

There are really good science teachers still out there.

Neil Bruce,
Tarragindi, Qld.

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Mailbag: continued

NBN is much more reliable

Your Publisher's Letter on the topic of the National Broadband Network (September 2012) hit the nail on the head. The old copper network and DSL both have reliability issues, the latter being affected by the quality of the former as well as other variables such as total loop length and the quality of internal cabling in premises.

It is, in fact, the relative reliability and stability of the new fibre network connections that actually makes its future quite a bit more attractive and, in some cases, even viable to service providers.

I work in a technical role with a small start-up company whose business model is to operate a "cloud-hosted" IP PBX solution and provide phone system solutions to schools that are connected to New Zealand's "UFB" and "RBI" fibre networks. Very broadly speaking, UFB & RBI are New Zealand's version of the NBN.

Fibre only started to become available here in NZ recently through these government projects (although there have certainly been some other private-business offerings before UFB/RBI). The schools get priority for connections to the new networks and hence have been first to come aboard with us, although we anticipate considerable market growth when general business customers come on in higher numbers over the next 5+ years.

The key aspect of these new fibre connections for us has been their reliability. Compared to DSL, they are just amazing. Our type of network traffic doesn't need vast quantities of bandwidth (an uncompressed VoIP channel only uses 64Kbit/sec in each direction), however it really does require excellent network quality. By that I mean near-zero packet loss, the lowest latency possible and and low jitter rates.

Fibre outperforms the DSL variants in all of these areas, as well as link-state reliability (ie, "keeping it up"). The excess bandwidth is an added benefit in more ways than one too; it's great for downloads but it also means less reliance is made on QoS (Quality of Service) technologies built into routers, switches and firewalls. QoS simply isn't required on uncontested links.

The reliability of the fibre connections is a absolute key part of delivering our particular service and this is why we have adopted a policy of only selling to those who are connected by fibre. DSL and copper, while technically capable of VoIP, are just too unstable for our business and reputation to be reliant on them.

My take on it is that it's a great thing that our governments are installing these cutting-edge new networks. Sure the implementations have been poor in some areas but what government project would ever be complete without budget overruns and missed deadlines? The new networks are creating opportunities for those on the technical cutting edge and our new company is just one example of what I am sure will be many more to come.

Pete Mundy,
Fiberphone Ltd,
Nelson, NZ.

had many an experience with these preset pots not being very reliable in the past.

Peter Walsham,
Pukekohe, NZ.

A bigger inverter is the answer for powering a chest freezer

With reference to your answer on "Trying the SoftStarter with an Inverter(2)" (Silicon Chip, August 2012, page 97), I don't think you went far enough in discouraging P. B. from using a SoftStarter with his chest freezer to reduce the required power rating of his intended inverter.

The torque-speed curves of a refrigerant compressor vane heat-pump or piston heat-pump are very different to a free-running centrifugal water pump. A freezer compressor has a relatively large torque requirement at start-up, which is precisely when the single-phase motor has its lowest torque rating even though it is drawing a large current.

Add to that the distinct possibility that the high and low sides of the refrigerant system may not have had time to completely equalise pressures before the initiation of a new cycle, further increasing the torque requirement for the rotor to start rotating. Also today's system designers seem to opt for minimum sizing in components that will only function correctly under near optimum conditions, so you don't have any leeway to further reduce the starting torque available by lowering the available voltage/current via a soft-starter.

The repeated current draw of a stalled rotor motor over a period of time will cause excessive heating of the motor field coils (both start and run) leading to field insulation breakdown and motor burn-out. Residue from that burn-out will go throughout the entire refrigeration circuit, leading to a major repair job and bill.

So P. B. should do the smart thing, not the cheap thing. Forget the SoftStarter, get the next size up inverter and hope you didn't skimp on the batteries so they can supply and sustain the surge current without excessive voltage droop.

If you have to pay for a refrigeration tradesman to replace a burnt-out freezer compressor, then it will make paying for an up-graded inverter seem very reasonable.

Trevor Krause,
Gympie, Qld.

Eddystone 898 dial wanted for Deltahet receiver

Can anyone help me in locating an Eddystone 898 dial assembly? As a radio trade apprentice at Philips Hendon, back in the early 1970s, I started to build the *Electronics Australia* Deltahet Mk.2 communications receiver. Due due to lack of funds, (earning about $17.00 a week!), I could not afford the dial assembly.

Now some 40 years later I have rediscovered my almost-built receiver, cleaned off the dust and am now on a mission to finally complete it! It is

on my bucket list! It has all been built as per the original articles, including most of the tag-strip layouts (except the rotary switches are pushbutton). The chassis is fully built; all the coils and ferrite transformers are built.

But I need to obtain the dial assembly and if possible the associated tunable IF triple-gang variable capacitor; from memory it was a triple-gang 415pF job. If anyone can help with the above, it would be greatly appreciated. My contact details are below.

James Tovo,
Redwood Park, SA.
Phone (08) 8289 1672.
Mobile 0401 087 812.

Nissan LEAF is uneconomic

That was a very interesting article on the Nissan LEAF and very revealing about the car and the Support and Marketing Team around it and what they know (August 2012).

As you say, the existence of these vehicles is all part of an interesting debate and you are right: it wasn't the world's first purpose-built mass produced electric car. Driving one should be a breeze with the simplified controls however my basic "beef" is around the cost of the vehicle and the cost of operation which encompasses the cost of replacing the batteries.

I would hope the electric motor has a long and joyous life. Let's look at some of the costs – I don't believe that any of them will "recharge for pennies" – maybe for hundreds of pennies, yes. I made a quick calculation and 230VAC for 14 hours at, say, 15A is 48.3kWh and at my current power cost this is $12.25 (rounded). Let's say we round that down a bit for the 24kWh battery pack capacity and make it $9.00 – this cost fits in well with your figures.

This cannot be compared to the $50 to $70 to fill an internal combustion (IC) engine-powered vehicle as they all will do many more kilometres per "fill" than the LEAF. If we make a real and correct comparison using

Nikola Tesla claimed by two nations

I have a correction to your article on the "Speed Control for Induction Motors" in the April 2012 issue. Under the heading on Induction Motors. You stated "Invented in the 1880s by the Croatian engineering genius Nikola Tesla".

Nikola Tesla was Serbian, not Croatian – see **http://en.wikipedia.org/wiki/Nikola_Tesla**

Calling Nikola Tesla a Croatian is offensive to the Serbian community in Australia and as a whole. Furthermore, it is also important that you publish correct facts in your magazine. As a long time reader/subscriber of SILICON CHIP I would appreciate if you could publish a correction.

John Lemic,
Lethbridge, Vic.

*Comment: this is bound to be controversial as both nations claim Tesla as their own. As Tesla himself once said, "I am equally proud of my Serbian origin and my Croatian fatherland" – see **http://www.teslasociety.com/teslavillage.htm***

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Mailbag: continued

A mandated solution to loud adverts

I have seen a lot of correspondence in SILICON CHIP on the subject of annoyingly loud audio levels in radio & TV advertisements. I believe that the solution is simple: introduce a pad which is automatically switched into circuit at the station when ads are being aired. Start at (say) 5dB, and see if the public deems this to be acceptable; if not increase it as required.

The pad and switching in/out could be the station's responsibility and is easily implemented and policed. Feedback would come from the very sector which currently provides it and the final decisions could be arbitrated by an industry or governmental body.

This acknowledges that ad-makers (like record producers but more so) always compete with each other and the surrounding program to produce the loudest sounding signal. They all use audio level compression and a variety of other tools. In many cases, they deliberately push signal levels into so-called "soft clipping".

It sounds audibly horrendous but there is no way to stop this one-upmanship. The best solution in my view is to apply an equal handicap across the entire industry and hopefully globally, and let the advertisers go for it. Of course, the result would fall short of 100% modulation and they would all scream "unfair" but that's life.

I would be interested to hear other readers comments as, to my knowledge, this is the first time such a proposal has been aired. My feeling is that by using this mechanism we could arrive at an acceptable degree of attenuation quickly and in a politically-correct way. Perceptual loudness analysis is great but nothing beats real life feedback.

Brett Crossley,
Castle Hill, NSW.

an ICE-powered vehicle which does 7l/100km, then it will do about 470km on a "fill". If we translate that to the absolute best that the LEAF will do, then the LEAF costs about $27 for the same distance for a "fill". So there is a saving.

If driving and charging habits impact battery life and thus distance travelled from a "fill", then LEAF costs will rise to maybe $35 – still about a 50% saving. There are other costs though and I recall writing an article a few months back where I reported some industry research that showed a LEAF Charging Station had been reduced in cost to make it more attractive and the cost reduction was $9000! I am very pleased to see now that we have a Home Fast Charger that costs $2200. But we now have another problem – if the owner only uses the Fast Charger then battery life is shortened. So the thing that people might want is not good for the car.

Now let's think about battery life. Bringing some pragmatism into this from the last 30 years or so, I reckon the battery "world" is worse than the IT "world" in terms of unfulfilled promises. I would fully expect that Nissan would be hugely optimistic about battery life when the batteries cost $10,000 in a $50,000 car.

And they have a warranty – hmm. I used Optima batteries in our vintage cars and modern car for a time and while they were good, they did not last quite the 10 years promised by the USA warranty – in fact Australia did not have that 10-year guarantee at all. It was quite different and much less. So I have no confidence that the LEAF battery will last 15 years – maybe even the car will not last that long.

Additionally, if the vehicle gets to be 10 years old and the battery is failing, how many consumers and their spouses will agree to putting out even $5000 to change it? The reality of long guarantees is the exquisite semantics used to escape obligations by dumping the problem back on the user. So all in all, it's a neat and quiet car and should be a snap to drive. But on a

Total Cost of Ownership basis which is the ONLY way to assess car costs, I suspect it will not stand up as the best economic choice.

On a different topic, I totally agree with that response to the person who wrote in about Brown's Gas (Ask Silicon Chip, August 2012, page 96). It's just tragic that there are people with so little understanding that they actually believe that an internal combustion engine can run on an incombustible material called water. It's right up there with the Pogue carburettor which for 50 years or so has promised 150-200mpg or so on a normal car but it too has been mysteriously suppressed by the "classic conspirators".

There is plenty of information on Pogue's and Brown's carburettors and a number of others and anyone can build one if they like – so I tend to put that in with Brown's Gas and "personal methane".

Ranald Grant,
Bellbowrie, Qld.

Unusual design features in Philips radios

The story in Vintage Radio in the August 2012 issue has prompted me to comment. Most old Philips radios have at least one unusual or weird feature. In the case of the BX373A, it is the elevated AZ1 rectifier. The explanation is that the chassis design is copied from earlier models (such as the 209U of 1945/1946) which had a transformerless circuit with a UY1N or UY21 half-wave rectifier. These were narrower than the AZ1 and had smaller bases (octal and Loktal respectively).

Having decided to include a gramophone pick-up connection, Philips may have decided that the transformerless design was unsafe (there would be a risk of the pick-up being live). At that stage, they did not seem to have any compact full-wave rectifiers like the AZ21, 7Y4, 5Y3GT, 6X5GT/EZ35, etc so they went back to the tried and true AZ1 that they had made since 1935.

Other radio manufacturers at that time used the same receiving valve line-up with the Loktal AZ21 rectifier but Philips never made them, probably for some reason connected with licensing.

When using the gramophone pick-

Using Press'n'Peel to make PCBs

I have been using Press'n'Peel film to make PCBs for quite some time now using an iron and have had very good results. When I saw your article in the February 2012 issue, I decided to get a laminator next time I had a chance.

When I tried this method I found the results were OK but when I went to clean the toner off the PCB after etching I found it came off far too easily. This will cause under-etching and a lot more touch-ups with a felt pen. The problem is the laminator does not get hot enough to fuse the toner properly – it needs to get to almost 300°C.

Ironing the film onto the PCB makes the toner stick a lot better but I have found problems with some small sections of the PCB where the toner doesn't stick at all. I found this was due to uneven bench surfaces and uneven PCBs with a slight warp in them. I even found I could cause the same section of the board to fail by putting it on certain spots of my bench when ironing it.

I decided to experiment and found a combination of both methods that works perfectly every time. First, I pass the PCB and film through the laminator after the film is well and truly stuck to the PCB (around 15 to 20 passes through the laminator). I then place it on the bench and place an A4 sheet of blank paper over the top and iron it with a light pressure for 4-5 minutes. I then pass the PCB through the laminator 20 more times and then run it under water and remove the film.

I have made SMT PCBs with 2-thou tracks this way and I believe that even finer detail could be achieved with this method.

Kyron Low,
Kenwick,WA.

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Mailbag: continued

Correction on Reality Technologies electrostatic panels

Thank you for the Product Showcase on our electrostatic panels in the September 2012 issue (page 52). Unfortunately, there is a small error that can expose us to legal problems with Liquid Base Pty Ltd, the manufacturers and distributors of the "Sonic Blade" speakers.

The article states we are the importers and that we can arrange for the manufacture of the Sonic Blades at low cost. In fact, we are an OEM supplier of our panel and technology to Liquid Base.

Could you please publish a correction stating that the Sonic Blades are the product of Liquid Base and that we are the supplier of the panels. Their website is **http://liquidbase.com.au**

Charles Van Dongen,
Chief Technical Officer,
Reality Technologies Australia,
Braeside, Vic.

up, the radio should be muted or there is a risk of hearing both sources together. In this set, when using the gramophone pick-up, the DC return in the detector circuit is broken. This means that the detector diode does not conduct, so it cannot produce any audio output.

Because the AF preamplifier and the AF amplifier are both in the same valve envelope, there is some risk of IF being detected in the triode, leading to residual audio even with the volume control down. However, the Loktal valve series are quite well shielded, so this was probably not a serious issue in this set.

Robert H. Bennett,
Auckland, NZ.

Loud adverts need a campaign

Thank you for your editorial in the February 2012 issue prompted by the American Federal Communications Commission response to loud TV advertisements. However, the editorial was a disappointment as you appeared resigned to a sunken lounge chair fate with the only recourse being to use the remote control. I would have hoped that your magazine could have included an informative "petition letter" that could have allowed readers to sign and send to the appropriate minister or authority. An editorial was spent on the subject, so it is obviously an issue of contention.

If such a petition letter was constructed, it could be forwarded to the editors of other relevant magazines for a more powerful movement. I suppose any magazine whose readers also watch Australian TV would be relevant! The pen is mightier than the sword. I would like to think a united pen would be more powerful than isolated remote controls.

With respect to Greg Mayman in the Mailbag pages of

the same issue, requesting an audio recorder, I could possibly suggest the Sony PCM-M10 Portable Audio Recorder. I needed to send a recorder overseas for conservation efforts and from extensive web searches, this appeared probably the ideal, though more expensive models exist. At the time the cheapest place was **bhphotovideo.com**

With respect to the Crystal Audio DAC chip upgrade in the February 2012 issue and the published specifications to delineate the differences and improvements, there is one specification missing. When looking through the specifications for audiophile gear relying on DACs, there appears one specification that appears correlated to the purchasing price when specs such as frequency response, distortion and signal-to-noise ratio have already been surpassed or evened-out in a lower-priced model. The specification not tested for in the article is dynamic range.

For the dynamic range of CDs, this specification is usually also surpassed by lower-priced models. But for deeper bit-depth audio sources such as SACDs, DVD-Audio, Blu-ray and 24-bit recordings, the price of gear goes up by hundreds for each decibel or so. For normal good gear, who can perceive the differences in signal-to-noise ratios or harmonic distortion anyway, even when the differences may be large between models but nevertheless minuscule in absolute terms?

I am not sure how the linearity chart and signal-to-noise ratio may relate to this but in the Features & Specification table for the article, it would have been good if dynamic range was also listed as a discrete value. What is the difference for the two chips for this?

Finally, with respect to ultrasonic anti-fouling units, as published in your September & November 2010 issues, what is the environmental impact of such units and has this ever been considered or monitored? If such units effectively ward off (or kill?) tough micro-organism growth, what the hell could it be doing to aquatic critters near the vicinity of the vessels? Are we creating torture (and death?) zones around such vessels when moored? Ultrasonic cleaners can punch holes through immersed foil, so how far are the anti-life waves travelling from such fitted marine vessels? If no-one knows, the mind boggles at what could be happening.

I've tried to find out myself using Google but all I got was an avalanche of how good such units are and how environmentally friendly they are. All marketing. Sure, they are environmentally friendly chemically but what about acoustically/physically?

So I tried another tack; I Googled for swimming near such devices. Not much came up but what did recommended not swimming near them. The alternative system uses a bow and stern copper electrode in the water with an impressed current when the boat is not in use. It would be good to know if the environmental impact for the ultrasonic devices has been fully assessed.

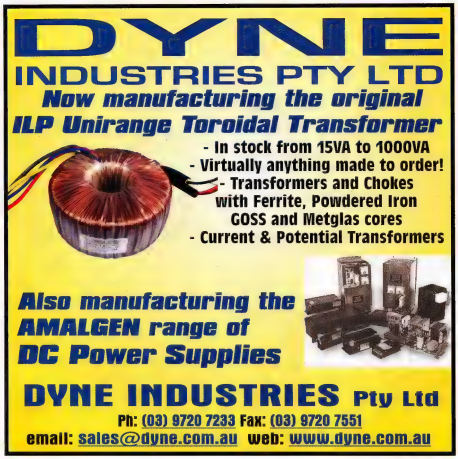
Paul Rohde,
Croydon NSW.

Comment: we have been involved in trying to organise petitions before and got absolutely nowhere.

As you say, dynamic range is normally limited by the digital bit depth, so for 16-bit content such as CDs it is limited to 96dB; with 24-bit content, noise is the limitation. For both DAC chips, the specified dynamic range is essentially the same as the signal-to-noise ratio - 123dB for the DSD1796 and 120dB for the CS4398. So the dynamic range figure doesn't tell us anything that the signal-to-noise ratio and distortion graphs don't. The advantage of the newer design is lower distortion.

As far as we know, ultrasonic anti-fouling signals have no effect on fish or other higher organisms. If you swim under a boat with ultrasonic anti-fouling turned on, you will feel considerable pressure in the ears, according to a number of reports we have seen.

However, ultrasonic algae control can be used in large fish ponds so there is no hazard in that respect. As far as alternative systems with floating copper electrodes are concerned, these are banned in some marinas because they can promote corrosion in nearby boats. SC



Electric RPAs... with wings!

by Bob Young*

In August, we looked at the burgeoning field of multi-rotor RPAs and SGMAs. But long before multi-rotor aircraft had enough computer grunt to actually keep them in the air, conventional (ie, fixed-wing) electric-powered model aircraft were being flown by radio control.

In this article we will be examining a small fixed wing Remotely Piloted Aircraft, designated as a Self-Guided Model Aircraft (SGMA) by the Model Aeronautical Association of Australia (MAAA) – and the technology incorporated into these little mini marvels.

Electric-powered RPAs

The choice of electric power as against internal combustion (IC) motors is a difficult one due to the severely limited energy density of batteries, even modern Lithium Polymer (LiPo) batteries.

Because of the severe power and endurance limitations currently imposed on electric powered RPAs, great care must be taken in the design and in-flight tuning.

However limited capacity not withstanding, the advent of the LiPO battery with its light weight and 3.7V terminal voltage has revolutionised electric flight for miniature aircraft. But they are still only suitable for short endurance flights at the moment, typically 15 to 120 minutes.

As we mentioned last month, electric powered aerobatic model aircraft are becoming a dominant force in international model aerobatic competitions, with over 50% of competitors now using electric power. This event only requires 15 minutes endurance and is thus ideal for electric power.

However, LiPos come with certain drawbacks including higher cost, they are easily damaged if not handled correctly and there is a higher risk of fire, especially in a crash.

In addition, charging is not a simple process, taking much longer than refilling a fuel tank and it usually involves

A transmitter not suitably equipped for LiPos in which the battery caught fire. Fortunately the fire burned itself out before any real damage was caused, probably due to a lack of oxygen in the battery box and carrying case.

Fig.1: this screen grab of the "Happy Killmore" Ground Control Station program shows an autonomous flight, plotted on Google Earth. Note the large variety of instruments and flight data available on screen – and there is much more data available under the various tabs and Google Earth settings. Happy Killmore GCS is a very powerful piece of software and it's free

multiple batteries to keep the flying session going.

Charging can occasionally be fraught with risk, especially when fast-charging. It is always a good idea to charge them on a fire-proof metal tray that can be easily carried outside in the event of a fire. And it is best not to leave them on their own when charging.

Fire is not a frequent occurrence but it does happen, particularly if the battery has been damaged in a crash. Models can be completely destroyed by the intense heat generated by burning LiPos.

When using LiPo batteries which can be damaged if the cell voltage falls below 3V so a low voltage alarm or cut-off is a must.

One word of warning here: there is a trend towards using LiPOs in transmitters which mostly (certainly older models) do not have low voltage cut-off. If that TX is left on inadvertently, then it is good-bye LiPo. So be very careful with this one.

However, this situation is rapidly changing, with faster-charging batteries and improvements in battery construction coming thick and fast.

Even so, a twofold increase in energy density or even more is required to lift the electric RPA into the really useful endurance category enabling it to begin to compete successfully with the IC engine. Rumour has it that this improvement is not far away.

Despite the foregoing, there are numerous advantages to electric power, including an almost complete lack of motor vibration (a boon for aerial photography), increased reliability over IC engines, ease of starting, the possibility of stopping and starting the motor in flight, (a great aid to increased flight times and further reducing vibration) and finally, an almost complete lack of noise.

In view of these advantages, the Author would use electric power exclusively were it not for the limited endurance.

Before we move on to an analysis of the electric motor and electronic speed controller (ESC) in the Cub, perhaps a few words on electric power are in order.

The table below is a widely understood, rough guide to the power required for different model types.

The "watts per kilogram" rating is calculated by dividing the wattage available to the motor by the gross take-off weight of the model in kilograms (kg).

20-30 W/kg:	Minimum level of power for decent performance, good for lightly-loaded slow flyer and park flyer models
30-40 W/kg:	Trainer and slow flying scale models
40-50 W/kg:	Sport aerobatic and fast flying scale models
50-60 W/kg:	Advanced aerobatic and high-speed models
60-70 W/kg:	Lightly loaded 3D models and ducted fans
70-90+ W/kg:	Unlimited performance 3D models

The wattage available is one thing but that wattage must be transformed into thrust – and that is accomplished via the propeller. Broadly speaking, as with all prop-driven aircraft, the

Not all SGMAs (self-guided model aircraft) are ten pound weaklings! This Flamingo, designed and built by the Author, is twice as long as he is tall and is powered by a "pusher" Moki 135 glow-plug motor. Actually this one is designated as an RPA because it is intended for commercial and even (hush hush!) military use.

bigger the prop, the more thrust it will deliver but with a consequent increase in required input power.

However electric motor theory tells us that the lowest current draw will occur with the motor unloaded, thus again broadly speaking, the smaller the prop, the lower the current consumption albeit with reduced thrust.

Aerodynamic theory tells us that in level flight thrust will equal drag, with the drag increasing with the square of the airspeed. Double the airspeed, four times the drag, so for the highest speed combined with the lowest drag (thus lowest current consumption) a high efficiency, low drag aircraft is called for.

Therefore the challenge for electric powered RPA designers is to get the correct mission-oriented balance between endurance and airspeed, by choosing the correct aircraft design, motor, battery and prop combination.

Thus we can now begin to see some of the problems for electric RPA designers. To get to the target quickly requires high speed but speed calls for a serious increase in current. Loitering over a target calls for a sailplane type aircraft that can virtually soar with the motor off.

As a matter of fact it is here that electric powered RPAs shine, as the motor can be easily stopped and started in flight and by using thermal soaring, endurance can be extended dramatically, certainly by at least two to three times the motor-run endurance.

So you see, the design and operation of an electric powered RPA is a very involved and delicate balancing act.

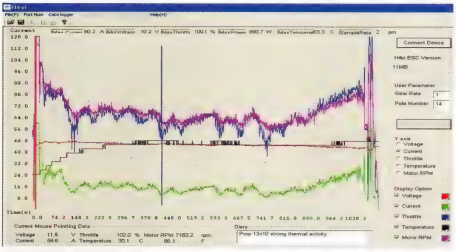


Fig.2: screen grab of the Electronic Speed Controller (ESC) data file for Flight 6. Note cursor (red line center) and data at the current cursor location (box bottom left). This flight is discussed in detail in the article.

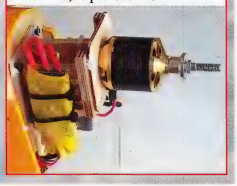
Piper Cub SGMA

The Piper Cub is obviously not the sort of aircraft discussed above. It is intended to be a pleasant to look at, easy-to-fly and boxy aircraft able to accommodate a wide range of test equipment, fit into the MAAA SGMA specs, teach people the fundamentals of RPA flight and serve as an example for articles such as this – all tasks it fulfils admirably.

This particular Cub is 1.9m (69") in wingspan, with over 1m^2 (670in^2) of wing area and a wing loading of 7900g/m^2 (26oz per square foot). Therefore it's a very lightly loaded and quite safe model as needed for training. It weighs 3.3kg (7.25lb), and is powered by a 780W Scorpion 3020/890 out-runner electric motor controlled by a data logging Electronic Speed Controller (ESC).

The Piper Cub self-guided model aircraft we're looking at in this feature. It has a 1.9m wingspan and weighs just 3.3kg.

Inset below: the Scorpion motor and ESC. The 3-phase leads to the motor are clearly visible in the fore-ground. Lurking in the background is a lead balance weigh. Note the toroid on the servo lead (just visible at bottom left) to prevent RFI.



The 890 is an interesting figure commonly used in out-runner motor specifications. This figure is a crude expression of rev/volt in an unloaded condition.

It is expressed as Kv – not to be confused with kV (Kilovolt).

Originally the Cub was fitted with a 2.4GHz manual control R/C system, an ATTOPilot autopilot V2 Thermopile autopilot and a 900MHz 9Xtend data link feeding data to a Happy Killmore Ground Control Station (GCS) on a laptop.

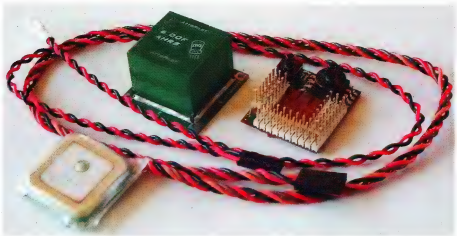
Power is provided by one or two (parallel) 3S (11.1V) 5,500mAh LiPo batteries. The endurance of the Cub is typically 10 – 20 minutes with one battery, depending upon the prop fitted. Airspeed is measured using a Pitot tube connected to the autopilot.

The Cub is not fitted with a camera. However, it could be fitted with one if required for the mission.

Under the bonnet

We will begin by examining the

Fitting out the body of an RPA or SGMA like this twin boom Flamingo is a matter of finding space for everything. Along with the radio control receiver, you need to find room for the motor (of course!) plus autopilot, attitude sensing, servos . . . and don't forget the batteries! This particular plane is powered by an internal combustion engine so a fuel tank is also required. Photo: Notre Dame University, Indiana, USA.



The ATTOPilot V3. From left to right: GPS module, 6 DOF IMU (6 Degrees of Freedom Inertial Management Unit) and ATTOPilot control board. The twisted pair is the cable for the LED which indicates the state of the Autopilot and GPS.

model from front to back. The 780W electric motor is a brushless outrunner driving props of various sizes, depending upon the mission requirements. The motor is controlled by a data logging ESC.

One of the nice features of modern processor-controlled electronic devices, in addition to their programmability, is their ability to record and graph almost everything that goes on inside that unit – and the units in a small RPA are no exception.

Good electronic speed controllers (ESC) used to control electric motors come with a built-in data logger which includes such valuable data as battery voltage, current consumption, RPM, ESC temperature and throttle setting, all plotted against time. This kind of data is invaluable when deciding upon motor types, prop sizes, battery capacity etc.

Modern ESCs are also fully programmable and feature a wide range of options, including:

- programmable low voltage cutoff
- programmable cutoff types (soft cutoff/hard cutoff)
- programmable brake type (disable/soft brake/hard brake)
- programmable time advance (low/standard/high)
- some are even programmable to brushed or brushless mode.

In Fig.2 we see a data graph for Flight 6, an early 20-minute test flight for this Cub, with the Y-axis calibrated for current. The Y-axis calibration can be changed simply by ticking the box at the middle right. This screen grab was chosen because it shows data which will be used in a later comparison with data graphs taken from the autopilot log for Flight 6.

Along the top of the graph are peak readings recorded during the flight. In this particular screen grab the mouse pointer (vertical red line at left) shows the voltage at cruise with the throttle at 46.6% as 11.2V, current 11.8A, thus power being 132W and RPM as 4321. (See Mouse pointing data box bottom left). The diary note bottom right notes that for this flight the prop was a 13 x 10 and there was strong thermal activity.

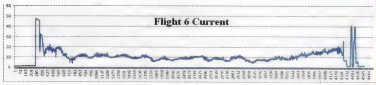


Fig.3: current graph for Flight 6 taken from the ATTOPilot log file shows a lower current reading than shown in Fig.2.

Fig.3, however, taken from the ATTOPilot log file, shows a similar graphic pattern but with a much lower current figure of approximately 8A. Calibration of the current draw was previously carried out with a 0 – 100A meter showing the A/P figure was correct.

So the moral is? Trust nothing and always calibrate where possible!

Thus we now have a take-off power of about 540W with a power loading of 33.86W/kg (74.5W/lb) but a cruise power of say 11.2V x 10A = 112W for a power loading of 7W/kg (15.5W/lb) for an average speed of 60km/h, a figure well below what is suggested in the power loading tables.

From the foregoing we can begin to see the enormous advantages that data logging provides for people interested in trying to get the best performance from any aircraft. Being able to compare motor power to airspeed now opens the way for some serious mathematical analysis of aerodynamic characteristics of the aircraft under examination.

For this reason alone, fitting this sort of equipment to an aircraft is a worthwhile exercise for any pilot serious about improving aerodynamic performance and endurance and the electric model in particular lends itself well to this sort of analysis.

2.4GHz radio control

The Digital Spread Spectrum (DSS) radio control system used in the Cub is a 2.4GHz 8-channel receiver running from a separate 6V battery driving

The Thermopile sensors on the Cub. Here the horizontal sensor set (Top of wing) is arranged in the "X" format. Note the calibration sensor (vertical) on the lower side.

four servos (elevator, rudder and two aileron servos) and the ESC.

For a full discussion on 2.4GHz DSS radios see SILICON CHIP February 2009.

It is advisable to use a separate RX battery rather than the ESC regulator for a variety of reasons. Amongst these are servo motor noise being induced into the receiver and to prevent overloading the ESC regulator when using more than three servos in the model. Also, the motor can take the main drive batteries to quite a low voltage under some conditions and one does not want to lose control when the receiver "browns out".

One of the nice things about 2.4GHz receivers is that they are largely immune to all of the little horrors such as interference from electric motor noise, servo noise, spark ignition noise and processor noise; all problems that sometimes caused the pilot serious grief when operating receivers working on 29 and 36MHz.

They are also immune from interference from other flyers operating on the same flying field. Thus frequency control is no longer a major issue.

The receiver used in the Cub features a fail-safe activated in the event of the TX being switched off in flight or an inadvertent loss of control signal. There are two fail-safe conditions, one in which the servos hold the last known position. The second fail-safe type sends the servos to pre-set positions.

When embarking on a long range flight (out of TX range) the TX is usually switched off and the last known servo position fail-safe is used. This keeps the RPA in trim while handing over to the autopilot which then takes control of the aircraft.

Autopilot

Here we arrive at the heart of the SGMA or RPA. An autopilot (A/P) is essentially a feedback system aimed at keeping the aircraft on a pre-plotted course, at a set airspeed and flying in straight and level flight unless changing course as directed by the A/P.

There is a wide variety of autopilots available, ranging in price from $500 to $50,000 or more. The difference in performance between the little low cost A/Ps and the high end models is staggering.

The low-cost units usually control only the rudder for GPS steering while the high end A/Ps coordinate turns using rudder and ailerons, feature excellent cross-track correction and give the appearance in flight of a piloted aircraft.

Plotted on a map, the high-end A/P flying a square or rectangular circuit will present sharp, right-angled corners with the sides absolutely straight and parallel and completely free of bowing due to an excellent cross-track correction system, eliminating sideways drift caused by wind.

One of the most popular A/Ps with the SGMA pilots and in the lower cost range is the little American ATTOPilot. The ATTO comes in two versions; the V2 is fitted with a Thermopile sensor for attitude control and the V3 comes with an inertial measurement unit (IMU). For the full story see www.attopilotinternational.com

The control board measures just 30 x 35mm and weighs 9 grams. The ATTO is a tiny package fitted with a staggering array of features and programming options. Here are just a few:

- stabilisation with automatic PID gain scheduling.
- gains for roll, pitch and yaw, adjusted continuously depending on airspeed.
- stabilisation gains tuned at any airspeed and they automatically adjust at other airspeeds
- proprietary navigation method automatically corrects for wind, flight speed and attitude.

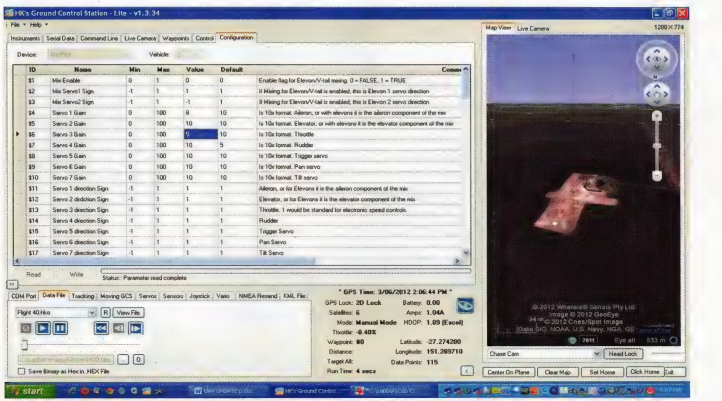


Fig.4: GCS showing some of the SET file parameters for Flight 40 just prior to uploading to the Cub. The Google Earth screen shows the Dalby (Qld) model field where these flights took place. It's one of the best model flying fields in Australia.

- airspeed can be controlled via pitch, throttle or a blended combination of both.
- likewise, altitude is controlled by throttle, pitch or a blended combination of both. Proportional blending of the two methods is possible over user-defined altitude bands and mix ratios.
- the processor is multi-core (8) and 32 bits, with 160 million instructions per second.
- on-board SD card data-logging provides a high bandwidth "Black Box" data record of all flights as comma-delimited text files with descriptive column headers.
- filename is based on flight date.

Unprecedented flexibility in setup

The user may define lists of mission-selectable loiter, radii and duration, as well as camera trigger repeat intervals based on either time or distance between trigger events. Flight plans can then be accessed via index number.

In addition, ATTO gives pilots over 120 configurable parameters that can be used to tailor the A/P for use in a wide variety of aircraft, from conventional monoplanes through to flying wings with elevons (combined ailerons/elevators). These parameters are accessed via the GCS under the configuration tab and then uploaded to the aircraft from the GCS.

These little RPAs may look and feel like toys but when combined with satellite-based GPS, long range data links and video downlinks, they represent a staggering achievement is terms of human endeavour. So much so, that Governments the world over worry about their ability to deliver lethal payloads and impose strict limits on their use including the mandatory RTL (return to launch) if the 300km-from-home limit is exceeded.

Attitude sensing

The ATTO V2 fitted to the Cub features a thermopile attitude sensor.

These sensors keep the aircraft level by looking at the horizon and comparing the temperatures on the left and right hand sides and the front and rear of the aircraft. They can be arranged in an "x" or "+" configuration and the autopilot calls for the correct arrangement to be programmed into the "SET" file.

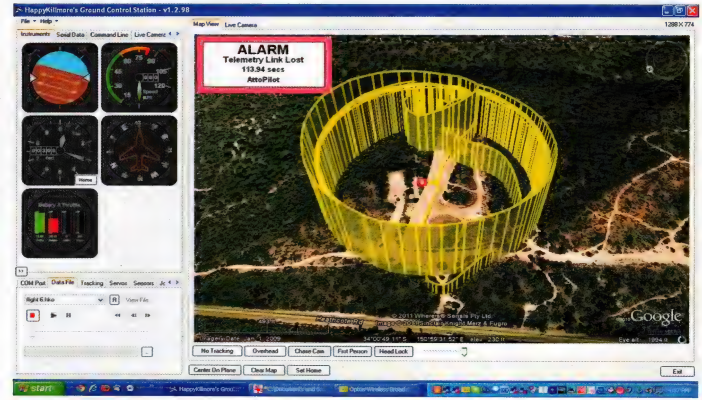
The ground temperature is always higher than the sky temperature and the small 2-element thermopile sensor mounted vertically on the side of the Cub compares the sky and ground temperature and provides the calibration for the horizontal sensors. There is no elaborate pre-flight fiddling with the ATTO V2 in regards to sensor calibration.

Thus in flight if the aircraft enters a dive the rear sensors looking at the sky record a lower temperature than the front sensors looking at the ground and it applies up-elevator correction.

In a climb, the action is reversed ,with a down-elevator correction as a result. Likewise, left or right rolling deviation from level flight will result in aileron corrections being applied to correct the roll and restore the aircraft to level flight. In this way the aircraft is held in straight and level flight at all times.

However there are limitations to the thermopile system. Fog, snow and glare from large bodies of water can reduce the system effectiveness. Nevertheless, the thermopile sensors work very well under most Australian conditions.

In one of the less pleasant affairs during a recent Dalby (Qld) trip the wind blew the aircraft off the table and it landed upside down on the sensor head, smashing one of the thermopiles.



A screen grab from the Happy Killmore GCS showing the track-plot of Flight Six painted on a Google Earth display. It is impossible to count the 16 orbits as they are all on top of one another. The Alarm sounds when the aircraft is recovered and switched off or if the data link is lost in flight. The vertical lines are called extrusions and are plotted upon receipt of each data packet. Uneven spacing indicates poor data reception.

RPA PIPER CUB'S FLIGHT 39

The 39th flight of the Piper Cub was a very early tuning flight for the Cub after being fitted with the V3 ATTOPilot autopilot.

The ATTO resides between the radio control receiver and the servos, and performs the stabilisation and navigation functions when the R/C transmitter is switched from manual mode to autonomous mode.

The graphs below are taken from the LOG file which records 49 data items, at a rate of four times per second.

The LOG file is in comma-separated format and can easily be imported into Excel for data analysis. It is invaluable when fine tuning the ATTO to the aircraft.

"Happy Killmore" Ground Control Station (GCS)

The GCS program used during this flight is the Happy Killmore GCS, version 1.3.34. It's a free download (with an option to donate) and you'll find it at **http://code.google.com/p/happykillmore-gcs/downloads/list**

This is excellent software and well worth a donation.

It allows programming of the waypoints directly onto a Google Earth map, as shown elsewhere in this feature.

The programmed course consisted of five waypoints aligned North/South and designed to force the Cub to perform left and right turns with two cross-wind, 700m long straight parallel runs. The flight was undertaken with a crosswind from the east gusting at 10-40km/h. Altitude was set at 120m AGL and air speed at 60km/h.

One final point on the HK GCS is the provision for a tracking antenna which will deliver optimum range for the data link. This automatically aims the antenna directly at the aircraft during flight.

Flight data analysis

Looking at the graphs, Fig.i shows the autonomous section of the flight. We can see that during Flight 39 the transmitter was switched from manual control into autonomous mode about 20s into the flight with the Cub well below the target altitude. The 20s was a minor mistake on the pilot's part as the autopilot prefers at least 30s of well-trimmed, stable, straight and level flight below the target altitude before switching into autonomous mode. The climb to target altitude took approximately another 35s at which point the Cub levels off exactly on altitude target with zero overshoot.

Fig.ii shows from that point on there are small variations in altitude of ±9m or less. While this is a less-than-ideal result, from the ground this level of deviation is not noticeable. A well-tuned ATTO will stay within ±3m from the target altitude when installed in an airframe designed to track well and respond rapidly to small control inputs. The Cub is not that sort of airframe and the results illustrate this point.

By far the weakest point in the ATTOPilot tuning at this point were the turns at the waypoints. Fig.iv shows the distance from each waypoint, with the long runs approximately 700m apart and the short runs approximately 200m.

Fig.v shows the distance from the planned flight path between waypoints. Note that Fig.v shows that the Cub hit each waypoint exactly on target. Fig.vi however shows that the ATTO is a bit soft on coming back on track after the turns but finally settling down almost exactly on track.

Thus the tuning needs to be more aggressive in regards to returning the Cub onto the track after turns. Better waypoint planning would also help in this regard. Longer straight runs even with this level of tuning would show excellent crosswind tracking accuracy and that is despite quite a strong crosswind component.

Finally, Fig.vi is a plot of airspeed against GPS groundspeed, showing a variation of 80km/h in the groundspeed indicating a headwind/tailwind component of 40km/h at various times during the flight. Once again we see indications of the airspeed tuning being insufficiently aggressive enough to hold the airspeed to the 60km/h target in these conditions.

All in all, the Cub and ATTOPilot handled well considering the weather conditions and the lack of fine tuning (on the ATTOPilot). The overall result was quite successful and would have resulted, even at this very early stage, in a very successful photographic aerial analysis of the area, had that been the planned outcome of the mission.

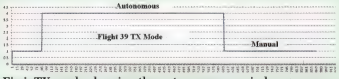


Fig.i: TX mode showing the autonomous period.

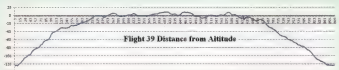


Fig.ii: The distance from the target altitude.

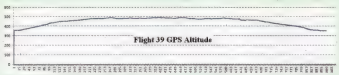


Fig.iii: GPS altitude.

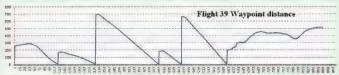


Fig.iv: the distance to each waypoint.

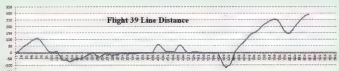


Fig.v: the distance from the planned flight path.

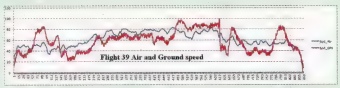


Fig.vi: air and ground speed

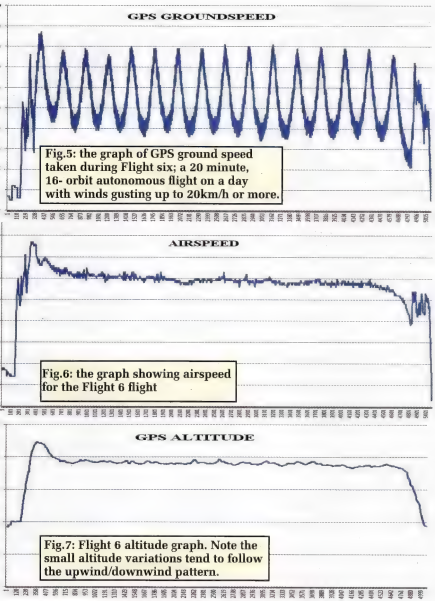


Fig.5: the graph of GPS ground speed taken during Flight six; a 20 minute, 16- orbit autonomous flight on a day with winds gusting up to 20km/h or more.

Fig.6: the graph showing airspeed for the Flight 6 flight

Fig.7: Flight 6 altitude graph. Note the small altitude variations tend to follow the upwind/downwind pattern.

The thermopile sensor was replaced with the inertial managent unit (IMU) and the V2 firmware updated to V3.5 firmware and flying continued despite the wind. The IMU is located inside the fuselage and is thus not exposed to this sort of danger.

The ATTO V3 uses the same control board as the V2 but with a 6-DOF (degrees of freedom) IMU instead of the thermopile sensors and carries more advanced software (V3.5). The IMU is a solid state device and works more precisely and responds more quickly than the thermopiles, giving the aircraft a crisper response to attitude changes.

While the thermopiles can in theory operate at night, something the Author has never tested personally, the IMU certainly can. The IMU also eliminates the above-mentioned thermopile limitations, thus the ATTOPilot V3 is a very sophisticated little unit and works extremely well in action.

Operational techniques

As mentioned previously one of the nice features of modern electronics devices is their recording ability and the ATTO is no exception.

The ATTO features two major file sets: the "SET" file in which the pilot sets the parameters for his particular aircraft and the "LOG" file which is the actual recording of the flight data.

It is the RPA operator's task to fine tune the values inserted into the SET file by test flying and examining the LOG file data and adjusting each parameter accordingly. ATTOPilot offer a good back-up service in this respect and will offer hints on tuning to the tyro Remote Pilot.

The LOG file begins by recording the data in the SET file so that the actual parameters used during that flight are available for future comparisons and then goes on to record the flight data.

The LOG file can be quite large in a long flight with 49 data columns recorded, data being updated four times a second in a comma-separated variable format. Thus the data can be inserted directly into an Excel spread sheet and graphed accordingly.

The actual flight under examination was a 20-minute flight in which the aircraft orbited a single waypoint 16 times in autonomous flight on a day with winds gusting up to 20km/h or more.

Thus we see the above graph indicating upwind/downwind ground speed variations of up to 40km/h during each orbit.

Fig.6 shows the airspeed on that flight and in theory that should remain constant throughout the flight as there is no upwind or downwind as far as the aircraft is concerned.

A glance at Fig.6 is all you need to confirm this was indeed the case. The slight variations in airspeed indicate a small degree of adjustment to the throttle gain value in the A/P SET file is required to overcome the small upwind/downwind variations in speed.

These graphs provide an invaluable service in fine tuning the A/P for best performance. The aircraft. when switched into autonomous mode was at a height in excess of the target cruise altitude of 90m above ground level (AGL) set in the A/P SET file.

Hence the aircraft dived to return to the target altitude thus increasing the airspeed temporarily until the system stabilised and entered the correct cruising airspeed envelope.

Once again referring to Fig.5, we can see that the elevator parameters are not set correctly with the altitude deviations while being close, are in excess of the ideal. And again we can just see the repetitive pattern of upwind/downwind variations. Altitude hold should be within ±3m in a well-tuned aircraft and ATTO.

Even so, the final result is quite good for an early test flight. SC

**** Bob Young is the principal of Silvertone Electronics, a company at the forefront of design and building radio controls (especially advanced digital) and remotely piloted aircraft such as the Silvertone Flamingo shown in this feature. Contact Bob on 0423 098 418***

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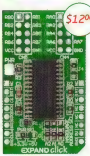

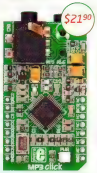

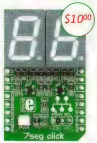

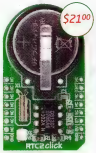

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HAARP – Research

If you believe the conspiracy theorists, HAARP is a "death ray", it can cause earthquakes, control weather, bring down aircraft . . . even cause buildings to disintegrate. But as we shall see, HAARP, the High Frequency Active Auroral Research Program facility in Alaska is a highly useful and promising research centre.

All radio enthusiasts, whether they are amateurs, shortwave listeners or DX TV enthusiasts, know that the ionosphere has a large influence on radio propagation.

For example, long-range radio communication relies on reflection or refraction of radio signals by the ionosphere to achieve range.

Without the ionosphere radio signals would continue in a straight line path out into space and would not reach a receiver located beyond the horizon.

Communications enabled by and affected by the ionosphere include those to and from transoceanic aircraft flights and ship-to-shore, international shortwave broadcasts, amateur radio and military communications, over-the-horizon radar and many others.

Signals that must travel *through* the ionosphere, such as those from GPS and other satellites, can also be affected.

In the case of GPS signals, errors are introduced to positional fixes due to random variations in the ionosphere. Because these are small, they're usually of no relevance to civilian GPS users. But they are important to users who require extremely high accuracy.

Unfortunately, the ionosphere is neither stable nor completely predictable and its properties are constantly varying according to the time of day, the season. the 11-year sunspot cycle

By Dr David Maddison

ing the Ionosphere

and other solar activity.

An example of ionospheric variation that is familiar to most people is that medium wave (MW) radio broadcast signals are carried much further at night than during the day. But changes in the ionosphere can occur extremely rapidly, even at time scales of as little as a second.

"Space weather"

Space weather refers to changes in the space environment, particularly the region between the Earth and Sun. The "solar wind" from the Sun streams past the Earth and is mostly deflected by the Earth's magnetic field but variations in the solar wind cause changes in the Earth's magnetic field.

Quite regularly, from about once per week up to a few times per day, a solar flare is produced on the Sun which is generated by a tremendous release of magnetic energy and results in the emission of X-rays and UV rays. These can interact with the ionosphere if the emission is directed toward the Earth.

In addition, electrons, protons, heavy ions and atoms may be simultaneously ejected from the Sun (called a coronal mass ejection event) and impact upon the Earth's magnetosphere. This can result in spectactular polar auroras. Also protons, which are travelling at up to about about one third of the speed of light, can constitute a serious radiation hazard for spacecraft and their occupants as well as a lesser hazard to aircraft.

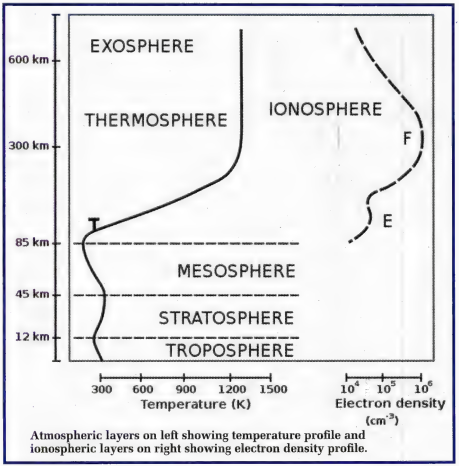
When a solar flare interacts with the Earth's atmosphere it can also result in damage to electrical power grids.

Here in Australia, from its office in central Sydney, the Ionospheric Prediction Service (IPS) monitors and forecasts space weather conditions, which include solar activity and geophysical and ionospheric conditions. Large numbers of radio users rely on the IPS data for their day-to-day radio operation. This government agency, (which now comes under the Bureau of Meteorology) has provided this service since 1947 (see www.ips.gov.au).

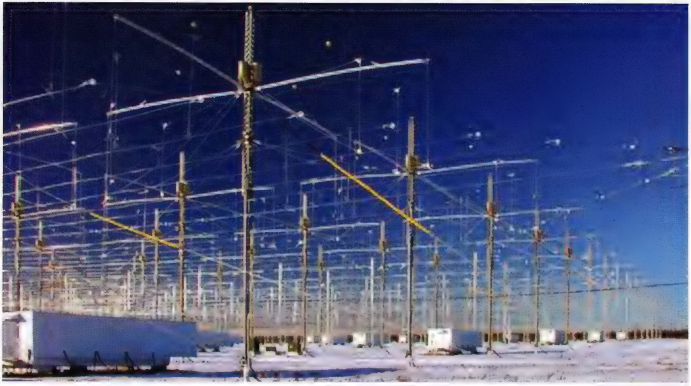
Space weather disturbances, which have a direct relationship with ionospheric conditions, can interrupt HF radio, imperil electrical power lines, threaten satellite transmissions and instruments (including avionics in extreme circumstances) and reduce the life of satellites in low earth orbits. They can even put long-distance pipelines at risk by reducing the efficiency of anti-corrosion cathode systems.

The ionosphere can reflect radio waves because it contains a significant proportion of charged particles in the form of atmospheric atoms which have had electrons removed by high energy radiation from the Sun, such as UV and X-rays as well as, to a lesser extent, cosmic rays from space. Such particles are said to be "ionised", leading to the name of the layer in which they exist.

These ionised particles form a plasma that is electrically conduc-



Atmospheric layers on left showing temperature profile and ionospheric layers on right showing electron density profile.



IRI transmitter array, view from NE corner. Each tower is approximately 22 metres tall and consists of both low band and high band dipoles and matching networks.

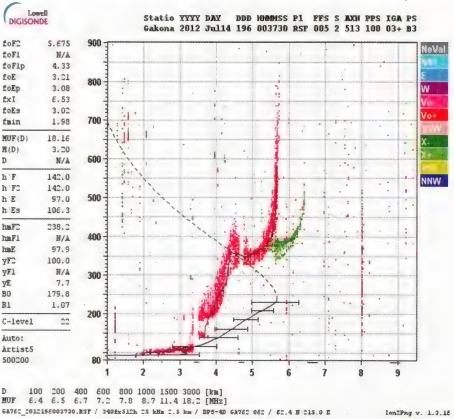
tive, capable of reflecting radio waves under the right circumstances. The exact properties of the ionosphere are determined by the balance achieved between the ionisation of gas atoms due to UV from the Sun and the atoms reverting to a "neutral" state after some period of time.

Typically, the ionosphere exists from around 85km altitude up to 600km, as shown in the diagram. Note that the ionosphere is superimposed upon the thermosphere and the exosphere.

Unlike the ionosphere, which is defined by its electrical properties (shown in the diagram in terms of electron density), these layers are defined by their temperature profile which is also shown.

By way of comparison, the ozone layer which protects life on Earth from excessive exposure to UV radiation occurs at an altitude of 20 to 30km and is located within the stratosphere.

The ionosphere has two main layers at which local maxima in electron density occur and these are called the E- and F-layers. During the night the F-layer (which splits into two layers, F1 and F2) is the only one that has significant ionisation, while during the day both the F- and the E-layers are significantly ionised. In addition, a D-layer forms beneath the E-layer.



Ionogram generated by digisonde with frequency along the horizontal axis and height in kilometres along the vertical axis. The coloured dots of the scatter plot indicate the altitude at which signals of a given frequency are reflected by the ionosphere and correspond to its various layers. The black solid and dotted line represents the electron density, which is related to the reflectivity of the ionosphere.

In the D-layer ionisation is low, hence it is not apparent in the electron density plot in the diagram but absorption of radio energy is high and it is responsible for the lack of long-range reception of medium wave AM broadcast band signals during the day.

The atmospheric pressure in which the ionosphere exists is extremely low – and is effectively space.

Consider that the International Space Station (ISS) orbits within the ionosphere and thermosphere at an altitude of around 320km. This is also the layer in which the polar auroras occur (the "northern" and "southern lights"), one of which forms the background to the panel below.

At altitudes much below the orbit of the ISS the atmosphere is too thin to support balloon flight (record maximum altitude 53km) but too thick to allow for observational satellites in stable orbits, so studying the ionosphere is difficult by conventional methods.

Hence, a ground-based ionospheric research facility such as HAARP is required.

HAARP experimental program

For reasons of the ionosphere's importance to radio and satellite communications and navigation, its instability and rapidly changing and incompletely predictable nature, the difficulty of studying it with either balloon-borne instrumentation or satellites, the HAARP facility was developed to enhance understanding of this atmospheric layer.

Optical instruments are housed in separate buildings, one of which has a large dome.

The traditional method of studying the ionosphere has been to transmit a signal and passively listen for a response. This has the disadvantage that the investigator is entirely reliant upon the vagaries of the ionosphere which, as stated, is unstable and subject to daily and seasonal variation.

This makes it very difficult to obtain data that are reproducible or that are based upon known ionospheric conditions.

HAARP does not just passively monitor processes and interactions as per the traditional methods, although it can do that as well. HAARP employs active methods, hence the use of that word in the project name.

It transmits extremely powerful radio waves that, according to Jim Battis of HAARP, are able to "create processes and interactions with the particles in the ionosphere and in some small area of the ionosphere, might trigger new processes or different responses which we can use".

The processes and interactions created by HAARP are more likely to be reproducible than with older passive methods.

A brief history of ionospheric research

Ionospheric research dates back as early as 1902 after Marconi made the first trans-Atlantic radio transmission. At that time it was not understood how radio waves propagated beyond the horizon and the two possibilities considered were that the radio wave underwent surface diffraction along the ground or that there was a reflective layer somewhere in the atmosphere.

American Arthur Kennelly and Englishman Oliver Heaviside in 1902 proposed that UV light from the sun could ionise atmospheric gases to make a conductive reflective layer. This layer came to be known as the Kennelly-Heaviside layer and is now known as the E layer, however its existence was not accepted at the time and propagation was thought to occur via surface diffraction.

Since longer wavelengths would have a longer range via surface diffraction, governments reserved these wavelengths leaving short wavelengths, which were thought to be useless, to amateurs. In November 1923, however, amateurs made the first successful two-way transatlantic radio conversation. This feat resulted in a renewed interest in the possible existence of a reflecting layer in the atmosphere.

Americans Gregory Breit and Merle Tuve in 1925 established evidence for the ionosphere by directing a pulsed radio signal upwards and detecting and measuring the time taken for a reflected signal. Knowing the speed of light, the height of the layer could be calculated. Much later, this work lead to the development of radar and also ionosondes (a radar-like instrument to measure properties of the ionosphere).

Later, these workers proved that radio waves were propagated via the reflecting layer by demonstrating that at a distant receiver a signal could be detected by first receiving a signal via a direct ground wave and a second signal via what must have been a reflected wave from the ionosphere.

The delay was also observed to vary at different times thus proving that the height of the layer was variable with time of day and season.

Englishmen Edward Appleton and Miles Barnett also in 1925 used continuous wave methods in their ionospheric research. In their first method, the angle of a received signal was measured and with knowledge of the distance between the stations the height of the reflecting layer could be determined. In their second method they used variable frequencies and an interference pattern established between a ground wave and reflected sky-wave from a closely located transmitter and receiver.

Properties of this pattern could be used to establish the height of the layer. Using shorter wavelengths they discovered the known reflective layer was penetrated and they discovered the existence of a second layer which came to be known as the Appleton layer, later to be called the F-layer. The D-layer was discovered some time after this in 1928.

During WWII long-distance radio communication was of particular importance and great efforts were made to develop predictive methods to ensure that the optimal transmitting frequencies and times could be used for maximum effectiveness.

Diagnostic Instrument Pad 3, showing both the classic riometer and the imaging riometer as well as other instruments.

To actively create or influence ionospheric processes HAARP utilises the Ionospheric Research Instrument (IRI) which consists of 180 crossed dipole transmitting antennas arranged in a 12 x 15 grid, spread over about 16 hectares. The transmitter, said to be the most powerful in the world, can transmit 3.6MW of power at frequencies of between 2.8MHz and 10MHz and the system is designed to have an effective radiated power (ERP) of between 400MW and 4GW (86 to 96dbW) depending on the frequency used. (The ERP takes into account the antenna gain of 31.6 dB, antenna input power and losses.)

Ionospheric heaters

Devices of this nature are generically known as ionospheric heaters because of their ability to heat (energise) the ionosphere. There are also similar but less powerful devices in Norway, Russia and elsewhere in the United States.

The signal from HAARP can be either pulsed or continuous and the transmitting antennas are arranged in a phased array configuration to enable the beam to be electronically steered. The beam, in the form of a 15° cone, is able to be steered and pointed to almost anywhere in the sky and its direction can be changed in around 15 milliseconds.

At the same time, the frequency can be changed within 10 to 20 seconds. The ability to steer the beam enables quick heating of multiple sections of the ionosphere to create a larger heated area.

The transmitted signal is directed upward toward the ionosphere where it is absorbed at an altitude of between 100 and 350km, depending upon the frequency used. The affected volume is of the order of hundreds of meters thick by tens of kilometres diameter.

The transmitted radio energy is either absorbed, causing some localised heating in the ionosphere, or causes optical emissions (akin to those generated in a fluorescent light bulb but generally too dim to see with the naked eye), or is reflected back to earth.

These effects can be monitored with radio receivers, radar and optical sensors at the HAARP facility.

Artificially energising the ionosphere with radio energy mimics the natural energising of the ionosphere by the Sun and other processes that occur within it but with a degree of control.

The amount of energy injected into the ionosphere, the frequency and the shape of the radio waveform and the direction of the beam (say, relative to earth's magnetic field) can be precisely controlled while ionospheric conditions before and after energising can be precisely measured.

Tests may be done at specific times when certain initial ionospheric conditions are determined to exist (eg, an experiment might require that the D-layer be absent).

Since natural ionospheric events are occuring at the same time as the artificially-induced ones, it is important to be able to distinguish between the two. Artificial events exist only during or shortly after the ionosphere is excited by the HAARP transmitter so artificially induced phenomena will correlate with transmitter activity.

Typically, experiments are repeated to confirm that it is the induced effects that are being observed.

Location

HAARP is located on a 14-hecare site at 62°N latitude, near Gakona, in Alaska. It's "miles from anywhere", actually on the site of a previous USAF over-the-horizon radar facility.

This ideal upper mid-latitude loca-

tion ensures that the facility experiences neither exclusively polar ionospheric conditions nor exclusively lower mid-latitude conditions. It is capable of making observations in both types of conditions depending on how far south the polar portion of the ionosphere is pushed. The remote location also offers relative radio quietness.

Safety

Despite the enormous power of the radio beam, the delivered signal in the ionosphere has an intensity of less than $3\mu W/cm^2$, which is five orders of magnitude less than the sun's natural radiation which reaches the earth's atmosphere (about $1.4W/cm^2$). In addition, any effects to the ionosphere dissipitate within seconds to minutes, once the transmitter is turned off. There is an Aircraft Alert Radar that will warn operators of approaching aircraft, so the transmitter can be shut down as a precaution against interference with avionics.

The Aircraft Alert Radar warns the HAARP operators if a plane is close to, or in, the operational area so the system can be shut off. There is a risk to the aircraft avionics if it enters the beam.

Power supply

During operation, HAARP goes "off grid" and generates its own power from four of its five 2.5MW diesel generators. Due to losses, it takes roughly 10MW of power to transmit 3.6MW of radio energy.

Findings and experiments

Since commencing operation HAARP has done much to advance knowledge of the ionosphere and the impact it has on radio communications, as well developing a deeper understanding of processes within it.

Research work has covered

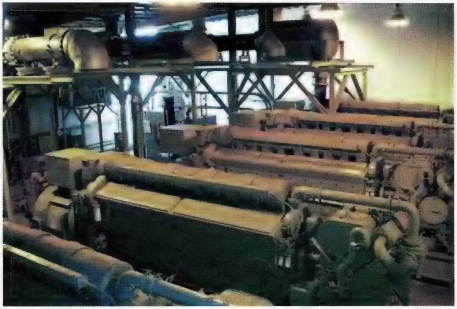
- Ionospheric heating, observations of natural and induced ionospheric plasmas
- Airglow due to ionospheric heating
- Electron emission from the ionosphere
- Scintillation studies
- Observations of meteors (which leave radio-reflective ionised trails)
- GPS signal propagation studies
- HF communications over polar regions, and
- Generation and studies of Extremely Low Frequency (ELF) (30Hz to 3kHz [this is the definition of ELF used by HAARP, other definitions vary]) and Very Low Frequency (VLF) (3kHz to 30kHz) waves including so-called "whistler mode" signals (a natural example of which are the electromagnetic waves in the audio-frequency range generated by lightning).

A notable HAARP accomplishment was, in 2005, the creation of an artificial green-coloured aurora that was visible to the naked eye (although this feat had also previously been achieved with the lower-powered EISCAT [European Incoherent Scatter Scientific Association] scatter radar systems in Norway).

Another interesting experiment undertaken in 2008 was to bounce 6.7 and 7.4MHz beams off the moon. While not strictly part of HAARP's primary scientific program, the moonbounce represented the lowest frequency ever reflected from the moon. Information was gained about lunar composition and about the beam's interaction with the ionsphere.

The bounce could be listened to by radio amateurs, some of whom reported a predicted 7Hz Doppler shift in the signal due to the motion of the moon.

An additional area of interest is the so-called electrojet, a region of



During transmitter operation, HAARP goes "off grid" and generates its own power from five 3600HP diesel generators. Four are used, with one available as a backup, giving a total power of 10MW from an installed capacity of 12.5MW.

HAARP Instrumentation

HAARP has a variety of instruments, divided into three broad categories:

1) active sensors which listen for a response after a radio signal has been injected into the ionosphere;
2) passive sensors that listen to signals naturally generated within the ionosphere and
3) optical sensors which are capable of seeing the light generated from an artificial aurora after the ionosphere has been energised by HAARP, although the light is not usually bright enough to see with the naked eye.

Riometer

A Riometer (Relative Ionospheric Opacity Meter) is a passive instrument that monitors natural background radio noise from the galaxy to establish the opacity or absorption of this noise by the ionosphere and thus provide a measure of ionospheric activity. It does this by monitoring such radio noise for an extended period of time during periods of low ionospheric activity to establish a baseline or "quiet-day curve". Any deviation from this baseline is a measure of increased ionospheric absorption and thus activity.

HAARP has a two types of riometer.

The first type is a classic "all sky" design that images most of the sky. In common with many other riometers this monitors the entire sky at a frequency of 30MHz.

The second type is an imaging riometer which, using a phased-array of narrow antenna beams is able to generate a two dimensional image of the sky showing local variations in ionospheric activity, such as might be generated by natural phenomena or ionospheric excitation by HAARP. This instrument operates at 37MHz.

Magnetometers

HAARP has both fluxgate and induction types of magnetometers, which measure small magnetic field variations caused by electrical currents in the ionosphere. The induction magnetometer measures the magnetic field in three axes and can measure fields down to as a little as a few picoTesla.

Digisonde

A digisonde is a radar-like device that probes the ionosphere with radio signals and uses information from the reflected signals to determine the present structure of the ionosphere. It is the same type of device as was formerly known as an ionosonde but it incorporates advanced computing methods and signal processing techniques to analyse the data.

Optical instruments

Among the optical instruments at HAARP are an all-sky imager, which can make observations at intensity levels way below what the human eye can sense and at a range of wavelengths.

There is also a telescope and photometers and a telescope dome and other instrument buildings (see photo of Diagnostic Instrument pad 3). The real-time results of the imager and other instruments can be seen on HAARP's data page.

VHF and UHF ionospheric radar

A VHF radar operates at 139MHz, while a UHF radar known as MUIR (Modular UHF Incoherent Scatter Radar) is used to make observations of the ionospheric plasma after it has been energised by HAARP.

Ionospheric Scintillation Receivers

Ionospheric scintillation refers to irregularities in the ionsophere caused by "space weather" such as solar and magetic storms. A suite of ionospheric scintillation receivers conduct research into this phenomenon and to assist in the development of predictive models.

Radio background receivers

HAARP has an off-site network of broadband ELF and VLF receivers used to monitor such signals naturally emanating from the ionosphere or those produced by artificially energising it.

The HF to UHF spectrum monitor has several purposes.

Firstly, it is used for self-monitoring to ensure an appropriate signal is being generated and radiated. Secondly, it is used to ensure that the transmitter is operating correctly and is not causing interference to other radio spectrum users. Thirdly, it listens for interference that may affect HAARP operations.

The output of this instrument set is presented in the form of a waterfall chart, available to the public on the HAARP website.

A waterfall chart will give a general indication of the ionosphere and show which frequencies are being propagated at any given time. A chart showing few colours indicates the ionosphere is not propagating signals well while one with many colours shows good propagation conditions.

The almost spartan HAARP control room belies its enormous capabilities and power.

extremely high electrical current flowing in the E-layer of the ionosphere in the vicinity of both the poles and the equator.

One area of research aims to generate ELF waves by using HAARP to modulate the electrical conductivity of the electrojet region. Since the electrojet current also has an electrical field associated with it, the result is an oscillating current which radiates at the modulation frequency. If the modulation frequency is in the ELF range a virtual ELF antenna is created in the sky, similarly for VLF frequencies.

The above result is of use because ELF and VLF transmitters often require infeasibly large antennae or power inputs. The ability to more easily generate ELF and VLF waves has applications in areas such as submarine communication and remote sensing of underground structures such as illegal nuclear weapon facilities. One HAARP committee report suggests that frequencies as low as 0.001Hz could be generated. Such a low frequency should be able to penetrate deeply into the Earth or ocean.

ELF and VLF waves will normally travel in the natural waveguide that is formed between the ionosphere and the earth. Some will however escape into space where they travel along magnetic field lines and return to Earth in the opposite hemisphere at the so called conjugate point, then are reflected and return to the transmitter. In one experiment, the return journey took some 8 seconds travelling at the speed of light. In contrast it takes light or radio waves about 2.6 seconds to return to Earth when reflected from the moon.

A novel proposed use of HAARP is to inject low frequency waves into the earth's radiation belts triggering the precipitation of charged particles thus enabling satellites to pass through these areas without risk of damage.

Other proposed uses including modifying the ionosphere to create reflecting over-the-horizon pathways for higher frequencies that would normally pass through the ionosphere into space.

Data availability

The real-time data output of most of HAARP's instruments is available publicly at www.haarp.alaska.edu/haarp/data.html

Conclusion

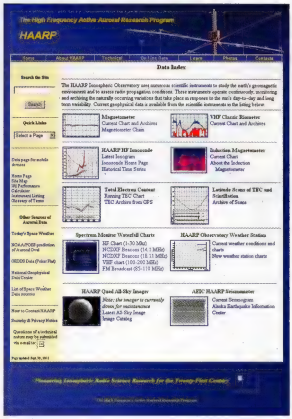
HAARP provides a unique facility to enable heating of the ionosphere in a controlled and reproducible way with a wide range of power levels, frequencies and modulation modes with the ability to rapidly steer the beam to produce desired patterns of energisation in the ionosphere.

Many diagnostic instruments are available to monitor the effects of this artificial energisation and their ability to remotely sense the ionosphere has been demonstrated.

Numerous areas of ionospheric behaviour can be explored and novel uses such as the production of ELF waves have been demonstrated.

Many new discoveries and uses are envisaged for this facility in the years ahead.

Want more information? You'll find a *lot* more at the HAARP website, www.haarp.alaska.edu – including the results of the many tests HAARP have and are running.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CHRISTMAS IS NOT far off so if you don't have a light show up and running already you'd better get started! Our new LED Musicolour makes it easier than ever. It drives up to 16 sets of LEDs directly. These can be strips, strings, single LEDs or a set – whatever, as long as they run off 12-24V DC.

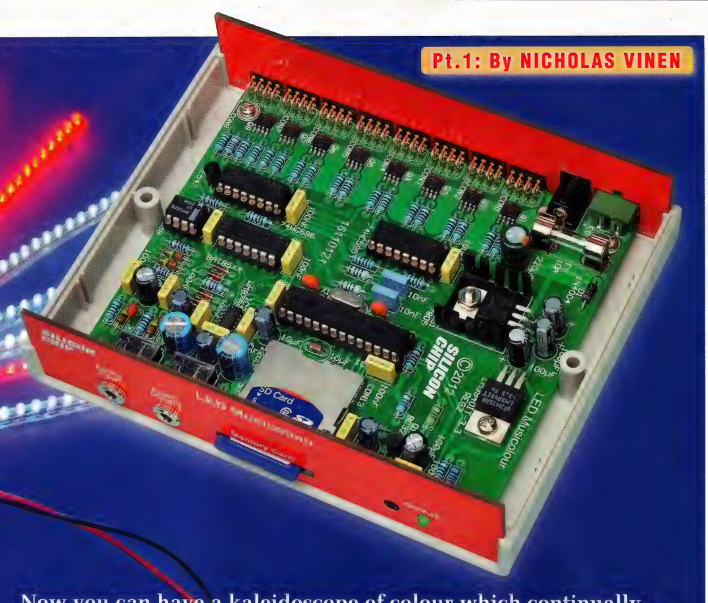
You can even build multiple LED Musicolours and run them in parallel, to control 32 or even 64 sets of LEDs.

You can drive the LED Musicolour using any line source such as CD or MP3 player, or you plug in an SD card which has been loaded with WAV files. In the latter case, it can be a self-contained sound and light controller with no need for any extra hardware apart from a power supply.

The unit supports high-capacity SDHC cards so you can load it up with lots of music (organised in folders) and use a universal infrared remote control to skip through them. If you build more than one, you can use one as the "master" to play the audio and feed it to the others for a synchronised light show, as well as to an amplifier so you can hear the music at the same time.

The LED Musicolour uses a 40MHz, 16-bit digital signal controller which is actually a specialised DSP (digital signal processor) microcontroller. It is powerful enough to do real-time frequency analysis using a Discrete Fourier Transform. The unit also incorporates a Wolfson WM8759 audio DAC for good-quality line level sound

Pt.1: By NICHOLAS VINEN



Now you can have a kaleidoscope of colour which continually changes in time to music. This consists of 16 strings of LEDs which are individually controlled by 16 frequency bands. Louder signals in each of those bands means that the respective LED string will be brighter. Use it for a Christmas light show, a disco or just for fun when playing music.

output. It all fits into a tiny plastic case which seems quite innocuous considering all the fancy processing it is performing.

Echoes of the past

This unit is intended as an easier-to-use version of the DSP Musicolour which was published in SILICON CHIP from June-August 2008. It was also somewhat inspired by the Digital Lighting Controller featured in the October-December 2010 issues.

The Digital Lighting Controller controls the brightness of up to 32 mains-powered lights or LED strips, in time to music. But its light sequences are pre-arranged, ie, you program a specific sequence to go along with each sound file. That is a somewhat laborious process but it gives you full control over the light show. It has no option to feed in external audio and its output sound quality is a bit so-so.

Also, the Digital Lighting Controller required you to build a master unit and between one and four slave units, with one slave controlling eight lights. The new LED Musicolour, on the other hand, is fully self-contained and can control 16 LED strips per unit. And as explained earlier, you can chain multiple LED Musicolour units together if you need to control more LEDs. So to sum up, the LED Musicolour is more flexible (having an audio input) and is easier to build and set up but doesn't give you quite as much control as the Digital Lighting Controller from

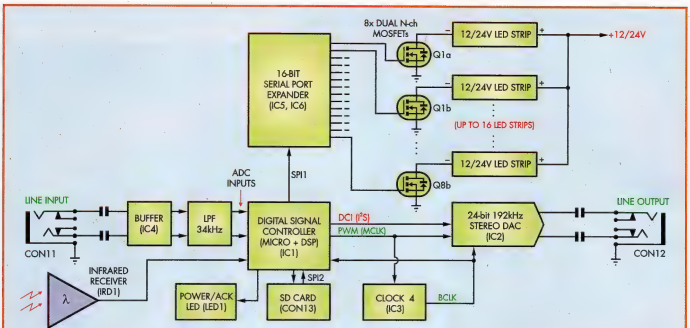


Fig.1: block diagram for the LED Musicolour. At its heart is IC1, a dsPIC33 Digital Signal Controller/Microcontroller. IC5 and IC6 are used to drive the Mosfets which control the brightness of up to 16 LED strips. Audio can either be fed in to CON11 or played back from an SD card in CON13, via stereo DAC IC2, to CON12.

2010. Having said that, the LED Musicolour's light shows are quite impressive and it is much simpler to build.

How it works

Take a look now at the block diagram of Fig.1. At its heart is IC1, a dsPIC33 digital signal controller (DSC). As stated above, this is a 40MHz 16-bit microcontroller and it features a fixed-point digital signal processing (DSP) unit and extra features to enhance its performance, such as multi-ported random access memory (RAM).

The brightness of the 16 strips of LEDs is controlled by switching 16 Mosfets at 200Hz, using pulse width modulation (PWM). IC1 only has 28 pins and that isn't enough to drive the Mosfets directly and leave some over for other purposes. So the Mosfet gates are driven from the outputs of two 8-bit serial-to-parallel latch ICs (IC5 & IC6) which act as a port expander. IC1 updates their output state using one of its internal Serial Peripheral Interface units, SPI1.

When a given output from IC5 or IC6 is high, this turns on the corresponding Mosfet, which sinks current from the negative supply line of the corresponding LED strip. The positive supply lines are permanently tied to the 12-24V supply. By controlling the proportion of the time that the Mosfet is on, we control the average current through the LED strip and therefore its brightness.

Audio can be fed into the unit via 3.5mm phono socket CON11. The audio signals (left & right) are then AC-coupled to IC4 which buffers them and applies a DC offset (~1.65V). This offset is necessary since the circuitry runs off a single DC supply rail.

Before being fed to IC1, the signals go through a low-pass filter with a corner frequency of 34kHz. This removes high-frequency signals which could cause aliasing when IC1 digitises the audio at a sampling rate of 48kHz, using its internal 12-bit analog-to-digital converter.

Alternatively, the unit can play back the audio from an SD card at CON13. IC1 reads WAV audio data off the card using its other SPI peripheral, SPI2. It then simultaneously analyses the data to determine the brightness of the LED strips and sends it to IC2, a stereo digital-to-analog converter (DAC), using its data converter interface (DCI) unit.

Audio data is transmitted from IC1 to IC2 in I^2S format. The DAC also requires a "master clock" which is a multiple of the sample clock – in this case, 192 times. For example, when playing 48kHz audio, the master clock is 9.216MHz. This is generated by IC1 using a PWM output, which outputs a rate proportional to its instruction clock.

The ratio we are using is 4:1, which gives an instruction clock of 34-37MHz, depending on the audio sampling rate. This is derived from an 8MHz crystal by changing the multiplication and division factors of IC1's internal phase-locked loop (PLL).

IC3 acts as a clock divider to convert the master clock (192 times sample rate) to the appropriate bit clock rate for the I^2S stream. This has a fixed ratio; we are transmitting 48 bits for each sample (24 per channel) which means we need a division ratio of $192 \div 48 = 4$. This bit clock is fed to both IC1 and IC2. The audio from IC2 is AC-coupled to CON12, a 3.5mm phono socket.

If you want to control the LED Musicolour with an infrared remote control, which is handy when playing back WAV files (but not strictly necessary), the commands are received by IRD1 and sent to IC1 which decodes them. The Power/Ack LED (LED1) flashes in response; it is normally lit while the unit is powered, to indicate that it is operating.

Circuit description

Refer now to Fig.2 for the full circuit details. As shown, IC1 sends serial data to and controls shift registers IC5

LED Musicolour Parts List

1 PCB, code 16110121, 103 x 118mm
1 front panel, code 16110122, 134.5 x 30mm
1 rear panel, code 16110123, 134.5 x 30mm
1 instrument case, 140 x 110 x 35mm (Jaycar HB5970, Altronics H0472)
1-16 12V or 24V LED strips with 2-pin or 4-pin sockets
1 12V or 24V DC power supply sufficient for LED strips
1 SD or SDHC card (optional)
1 universal infrared remote control (optional) (eg, Jaycar AR1726, Altronics A1012)
2 PCB-mount M205 fuse clips (F1)
1 10A M205 fuse (F1)
8 8-pin dual row right-angle pin headers, 2.54mm pitch (may be snapped from larger headers) (CON1-CON8)
1 PCB-mount DC socket (CON9)
1 2-way right-angle pluggable terminal block (CON10)
2 PCB-mount switched 3.5mm phono sockets (CON11, CON12)
1 Oupin SMD SD card socket (or equivalent) (CON13) (Altronics P5720)
1 8MHz HC-49 crystal (X1)
1 6073B type TO-220 heatsink (Jaycar HH8502, Altronics H0630)
1 M3 x 6mm machine screw
1 M3 x 10mm machine screw
2 M3 shakeproof washers
2 M3 hex nuts
4 No.4 x 9mm self-tapping screws
1 28-pin narrow IC socket
1 8-pin IC socket (optional)
1 14-pin IC socket (optional)
2 16-pin IC sockets (optional)

Semiconductors

1 dsPIC33FJ128GP802-I/SP microcontroller programmed with 1611012A.hex (IC1)
1 WM8759 24-bit 192kHz stereo DAC (IC2) (Element14 1776274)
1 74HC393 dual binary counter (IC3)
1 LM358 dual op amp (IC4)
2 74HC595 serial-to-parallel shift registers (IC5, IC6)
8 Si4944DY dual SMD Mosfets (or equivalent) (Q1-Q8) (Jaycar ZK8821)
1 BC547 NPN transistor (Q9)
1 BC327 PNP transistor (Q10)
1 7805T 5V 1A regulator (REG1)
1 LM3940IT-3.3 3.3V LDO regulator (REG2)
1 1N4004 1A diode (D1)
4 BAT85 small signal Schottky diodes (D2-D5)
1 green 3mm LED (LED1)
1 3-pin infrared receiver (IRD1) (Jaycar ZD1952, Altronics Z1611A)

Capacitors

1 220µF 25V low-ESR electrolytic
2 220µF 16V electrolytic
5 100µF 25V electrolytic
4 10µF 16V electrolytic
1 10µF 6V SMD ceramic (3216)
13 100nF MKT or MMC
2 10nF MKT or MMC
2 100pF ceramic
2 33pF ceramic

Resistors (0.25W, 1%)

2 1MΩ	6 1kΩ
2 120kΩ	2 470Ω
3 100kΩ	1 220Ω
3 47kΩ	19 100Ω
5 10kΩ	1 10Ω
1 4.7kΩ	

Note: the PCB and front & rear panels are available from the SILICON CHIP PartShop.

& IC6 using four data lines: DS (serial data), SRCK (serial clock), LCK (latch control) and MR (master reset). While microcontroller IC1 runs off 3.3V, IC5 and IC6 run off 5V, to drive Mosfets Q1a-Q8b with sufficient voltage to switch them on.

Unfortunately, a 74HC595 with a 5V supply will not work reliably with 3.3V input signals (according to the data sheet), so these signals need to be level shifted to 5V. For SRCK, DS and LCK, the corresponding IC1 pins (RB8, RB6 & RB5) are set as open drain outputs. These pins are 5V tolerant and with 1kΩ pull-up resistor to +5V, they can operate to at least 1MHz.

For MR, we have used a different arrangement as we want this line to be low by default, keeping the outputs of shift registers IC5 and IC6 off until IC1 brings it high. NPN transistor Q9 acts as an inverter/level shifter; the 100kΩ pull-up resistor between its base and collector holds it on when IC1 is not driving it.

IC5 and IC6 drive the Mosfet gates via 100Ω series resistors which form low-pass RC filters in conjunction with the Mosfet gate capacitances (about 1nF each). This prevents oscillation and overshoot when switching on or off, due to copper track inductance. We are using eight dual-Mosfets to keep the cost and size down. Each can switch up to 9.4A at 30V.

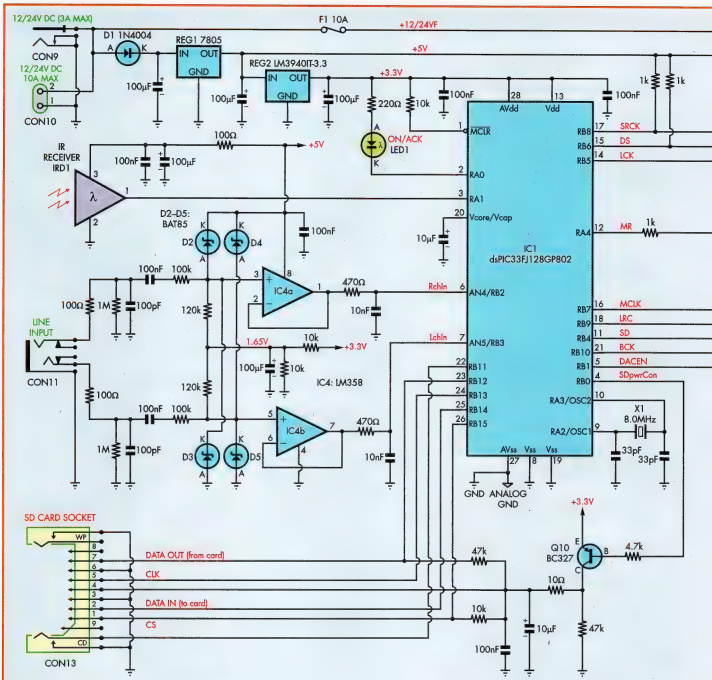
The LED strings are connected to a series of 4-pin headers. Their outer two pins are connected to the high side of the supply (12-24V) and the inner two to the Mosfet drain. That way, you can plug the LED strip connector in either way around and it will still work. It also gives more contact area to safely allow up to 2A per LED string.

Audio inputs

Turning now to the audio inputs, the left & right channel signals from CON11 first pass through low-pass RC filters consisting of 100Ω resistors and 100pF capacitors. These filters prevent RF (radio frequency) signals from entering the device. There are also 1MΩ bias resistors in case the source's output is AC-coupled. The value of these resistors can be lowered if you want to feed in the output of an iPod, eg, to 1kΩ each.

The signals are then AC-coupled by 100nF capacitors to a resistive divider/DC bias network. This forms a high-pass filter with a -3dB point at 7Hz. It also sets the input impedance of the device to 1MΩ || 220kΩ = 180kΩ.

The 100kΩ/120kΩ dividers allow an input signal of up to 2.2V RMS before clipping. The signal fed into IC1 is limited by its supply rails to 3.3V peak-to-peak. This translates to 3.3V ÷ (2√2) = 1.17V RMS. However, many CD/DVD/Blu-ray players, computers



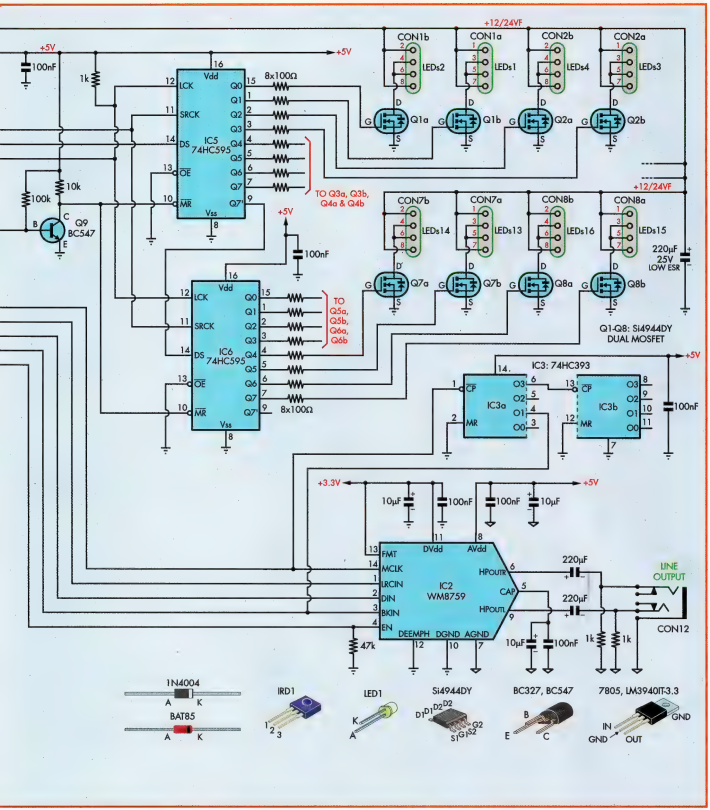
LED MUSICOLOUR

Fig.2: the LED Musicolour circuit diagram. Audio fed into CON11 is filtered, AC-coupled, attenuated, buffered and filtered again before passing to IC1's internal ADC. IC1 communicates with IC5 & IC6 via a serial (SPI) bus and these ICs drives Mosfets Q1a-Q8b. Another SPI bus is used to read/write the SD card in CON13 while a similar I²S serial bus is used to send audio data to stereo DAC IC2. IC3 ensures that the DAC's master clock (MCLK) and serial data bit clock (BCK) are synchronised.

and so on will put out 2V RMS or more. So we attenuate the signal by a factor of 120kΩ ÷ (100kΩ + 120kΩ) = 0.55 to allow for this.

The bottom end of these resistive dividers is connected to a half-supply point of about 1.65V, derived using two 10kΩ resistors and filtered by a 100µF capacitor. The signals fed to analog input pins AN4 and AN5 of IC1 thus swing symmetrically around its half-supply point. Op amps IC4a & IC4b buffer the input signal so that the following RC low-pass filter (470Ω/10nF) does not load up the signal source or previous stages.

Schottky diodes D2-D5 protect the inputs of IC4 from going outside its supply rails when the unit is not powered. While not strictly necessary, this makes the circuit more "bulletproof".



The low-pass RC filters following IC4a & IC4b both have a -3dB point of 34kHz and are tuned to the sampling rate of IC1's ADC (48kHz). If there is much signal above the Nyquist frequency (48kHz / 2 = 24kHz), this can cause aliasing which results in spurious sub-harmonics being detected. The filters (mostly) prevent that from happening.

Audio outputs

As explained earlier, the master clock for DAC IC2 (ie, from output RB7 of IC1) is generated by a PWM peripheral which divides IC1's instruction clock by four. This is fed to IC2 and also to IC3a's CP-bar clock input (pin 1). Its O1 output is one-quarter of the input frequency and this is the audio data bit clock, BCK. BCK is fed to both

Specifications

- **LED voltage:** 12-24V DC
- **LED current:** up to 10A total (ie, 120-240W maximum)
- **Number of LED strings:** up to 16 per unit
- **LED control method:** PWM, 200Hz, 255 brightness steps
- **LED connectors:** 2-pin or 4-pin male headers, 2.54mm pitch
- **Audio input:** 0.5-2.2V RMS nominal, 180kΩ || 100pF input impedance
- **Audio output:** 1.1V RMS, THD+N 0.004%, signal-to-noise ratio 100dB
- **Audio file support:** 8-48kHz 16-bit mono or stereo WAV files
- **Maximum directory depth:** eight levels
- **Maximum files per directory:** 100
- **Control method:** universal infrared remote (optional)
- **Dimensions:** 140 x 110 x 35mm
- **Supply voltage:** 12-24V DC
- **Current drain:** ~110mA at 12V

IC1 & IC2, which use it to send and receive the audio data respectively.

IC3a's O3 output (1/16th MCLK) is connected to input CP-bar of IC3b, the other half of the dual binary counter. This is for testing purposes; the IC3b outputs give various frequencies related to the sampling rate being used. For example, with a 48kHz sampling rate, pin 9 of IC3 (O2) will measure 72kHz (48kHz x 1.5) and pin 8 (O3) will measure 36kHz (48kHz x 0.75).

The I²S data stream from IC1's DCI peripheral comes from pins RB9 (LRC) and RB4 (SD). LRC is the left/right clock and represents the sampling rate (eg, 48kHz). It is produced by the data framing output of the DCI module. SD is the serial audio data and this is clocked according to the signal received at its RB10 input (pin 21).

By default, IC2 is in standby mode as its enable pin (pin 4) is pulled to ground by a 47kΩ resistor. When IC1 is transmitting audio, it brings output RB1 (pin 5) high, pulling IC2's enable pin high and thus turning on the DAC.

IC2 has a pair of bypass capacitors (MKT and electrolytic) between each pair of supply pins, digital (DVDD/GND) and analog (AVDD/AGND). Its format input (pin 13) is tied high to 3.3V, setting it to I²S mode. Its DEEMPH input (pin 12) is low since we don't need digital de-emphasis. A pair of capacitors between its CAP pin (pin 5) and AGND filter its internal half-supply rail.

Audio is available at HPOUTL (pin 9) and HPOUTR (pin 6). These signals are AC-coupled using 220µF electrolytic capacitors, as IC2 can drive loads down to 16Ω. The 1kΩ DC bias resistors set the average output level to 0V.

SD card interface

The SD card interface is quite simple and is a tweaked version of the same interface we have used in the past. Microcontroller input RB11 (pin 22) is connected to the socket's Card Detect line which is pulled to ground when a card is inserted. IC1's weak internal pull-up is enabled for RB11, allowing it to sense when this occurs.

The SD card is operated in 1-wire mode and IC1's SPI2 unit is used to send and receive data. This is mapped to pins RB15 (pin 26, card select), RB14 (pin 25, data to card), RB13 (pin 24, serial clock) and RB12 (pin 23, data from card). The card select (CS) and data from card (DATA OUT) lines are pulled up to V_{DD} to prevent any card operations from occurring when IC1 is reset or being programmed.

The SD card's V_{DD} line is not connected directly to 3.3V but rather switched by PNP transistor Q10, which is controlled by output RB0 (pin 4) of the micro. This allows it to turn power on for the card only after it has been inserted.

The associated 100nF and 10µF capacitors bypass the SD card's supply, while a 10Ω series resistor prevents excessive current from being pulled from the 3.3V rail when the SD card is first powered up. A 47kΩ bleeder resistor shunts any leakage from Q10 so that the supply bypass capacitors don't charge up when it is off.

Remaining parts

Infrared receiver IRD1 detects IR pulses from the remote and converts them into digital signals which it sends to input RA1 (pin 3) of IC1. IC1 then uses a pin-change interrupt handler routine to decode the Philips RC5-coded transmissions. IRD1 is powered from a 5V supply which is filtered using a 100Ω series resistor and 100µF and 100nF capacitors.

IC1 has two 100nF supply bypass capacitors, for its 3.3V V_{DD} and AV_{DD} lines, plus a 10µF capacitor on the output of its internal 2.5V regulator at pin 20 (V_{CAP}). A 10µF SMD monolithic ceramic capacitor is the preferred type here, as it has good performance and a long life. A 10µF through-hole tantalum capacitor could also be used and this is catered for in the PCB design.

Power indicator/acknowledge LED1 is switched from output RA0 (pin 2) of IC1. It's fed via a 220Ω series current-limiting resistor, giving a LED current of around 5mA when it is on, ie, when RA0 is driven low.

Power supply

The incoming 12-24V DC supply is applied to either DC socket CON9 (up to 3A) or to pluggable terminal block CON10 (up to 10A). The positive line is fed to the 16 LED strips via a 10A fuse, while a 220µF low-ESR electrolytic capacitor prevents the supply voltage from drooping too much when the LED strips are switched on in unison.

Current also flows from CON9/CON10 to 5V regulator REG1 via reverse polarity protection diode D1. The 5V output from REG1 powers infrared receiver IRD1, buffer op amp IC4, serial latches IC5 & IC6 and the analog section of DAC IC2.

REG2, 3.3V low-dropout regulator, is also fed from 5V and supplies power to the remaining components: microcontroller IC1, clock divider IC3, the SD card (via transistor Q10), LED1 and the digital section of DAC IC2.

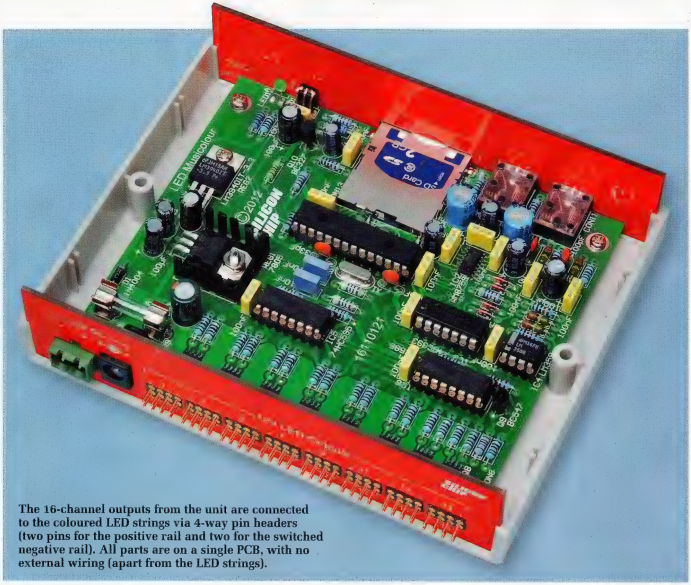
It also acts as the half-supply bias generator for the analog inputs (IC4a & IC4b).

Software

For those interested, the source code will be available for download from the SILICON CHIP website. We won't go into detail here but will just give some basic information on its operation.

IC1 only needs to shift one word of data (ie, 16 bits) to IC5/IC6 in order to update the state of all LED outputs. IC5 and IC6 are cascaded, with IC5's Q'H output going to IC6's serial input. This is triggered off one of IC1's internal timers that is set to a rate of 200Hz.

When the timer interrupt occurs, the SPI1 peripheral is used to shift a new word to IC5 & IC6, turning on any LEDs that have a brightness above zero. A second timer is then set to generate an interrupt at the time when the dim-



The 16-channel outputs from the unit are connected to the coloured LED strings via 4-way pin headers (two pins for the positive rail and two for the switched negative rail). All parts are on a single PCB, with no external wiring (apart from the LED strings).

mest LED strip needs to be turned off for the correct duty cycle; this delay is calculated as 5ms x (duty cycle) ÷ 100.

When this second interrupt is triggered, the handler routine turns off that LED strip and any others with an identical brightness, then re-schedules the timer for the next dimmest LED strip and so on. As a result, depending on the exact brightness value for each LED output, up to 200 x 16 = 3200 interrupts per second are needed to control the LEDs. Thus the overhead is relatively low, given that IC1 runs at around 35MHz.

The LED brightness is updated for every 1024 audio samples. A 1k Fast Fourier Transform (FFT) is then applied, with a Blackman-Harris window, to convert the time domain data to the frequency domain. The magnitudes of the resulting vectors are calculated, giving the frequency content for each bins and the bins are averaged in bands to give the brightness values for the LED outputs.

Audio playback

Since IC2 (the stereo DAC) has no volume control, we need the ability to digitally attenuate the audio data sent to it. Thus, we send 24-bit audio data, even though the WAV files only store 16-bit samples. They are converted to 24 bits by multiplying them by the 8-bit volume level.

For 48kHz audio, IC1's internal clock is set to 36.857MHz using its PLL (8MHz x 129 ÷ 28). MCLK is set to this frequency divided by four, ie, 9.214MHz and BCLK = 9.214MHz ÷ 4 = 2.304MHz. This is the rate at which audio data is serially transmitted to DAC IC2.

The DCI (data converter interface) is set to I^2S mode with 24 bits per sample, giving us a sample clock (LRCK) of 2.304MHz ÷ 24 ÷ 2 = 47.991kHz, which is very close to the target of 48kHz.

Getting the DCI to transmit 24-bit data is a little tricky since it works with 16-bit words. We set it to transmit two 12-bit words per sample and the audio data is stored in memory in 32-bit chunks, with eight bits of each unused.

The rest of the software is fairly straightforward and involves the reuse of much of our existing dsPIC33 codebase, including the SD card interface, FAT16/32 file system layer, interrupt-based infrared protocol decoding and so on. Besides the LED strip control, the main area of new code for this project is the audio playback layer which has been enhanced to support WAV files residing in multiple folder. It also supports folder hierarchies several levels deep.

That's all we have space for this month. Next month, we will describe the assembly and show you how to drive it. SC

Another project for DCC Model Railway enthusiasts . . .

Automatic reverse loop controller for DCC model railways

A "real" reversing loop at one of the Gladstone (Qld) bulk coal loaders. (Aerial photo courtesy Nearmap.com).

Many model railway layouts have reverse loops since they enable a whole train to travel back and forth along a length of single track and hence make operation more interesting. But reverse loops are a problem on DCC layouts as there is an inevitable short circuit as the loco crosses the points. This project solves that problem.

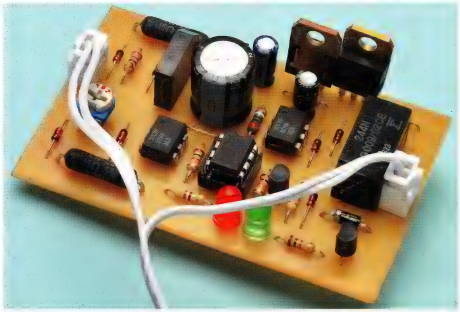
In the real world, reverse loops are used at the end of long section of track so that a complete train can change direction. They are used for large "block trains" which carry bulk loads like iron ore and coal. The train is unloaded at one end (usually without stopping) and then proceeds around the loop and goes back to be loaded again, perhaps hundreds of kilometres away at the mine.

The photo above is a satellite view of a real-world loop at one of the coal loaders in Gladstone, on the central Queensland coast. In fact, there are reverse loops for several coal loaders in Queensland and they used at other bulk loaders around Australia, so they are not simply a feature enjoyed by the model railway fraternity.

In the modelling world, a reverse loop (or two) on a layout will allow a train to change direction without it having to be physically picked up and swapped around. But as noted above, the model reverse loop has a serious problem which does not affect real-world railways – shorts in the track.

Note that while shorts in reverse loops are problem with all model railways, we should state at the outset that this project is only suitable for DCC layouts. For more information on DCC

By Jeff Monegal



It's all built on one small PCB with just two connectors – in (from tracks) and out (to reverse loop). Note that this will NOT work with DC or PWM setups!

operation have a look at the article in the February 2012 issue and the high power DCC booster project featured in the July 2012 issue.

To repeat, this project will ***not*** work on model railway layouts which employ conventional (ie, variable DC or PWM) controllers.

Fig.1a shows how a reverse loop works in a conventional layout. As you can see, a reverse loop has one set of points (in US parlance, switch or turnout) which is set one way to allow the train to enter the loop.

It is then set the other way to allow the train to travel out of the loop, in the opposite direction along the single track with the loco still leading the train.

However, if you follow the top (red) rail from point "A" all the way around the loop to point "B" you will see that there is a short circuit. The rail (red & black) colours in the diagram highlight this major problem on any model railway layout.

So what can be done?

One solution would be to cut the rails at two places inside the loop. These gaps are shown in Fig.1b. If we use a DPDT switch to connect power to the isolated section of the loop we can change the track polarity as the train traverses the loop. In effect, the loop is set to the same polarity as the track when the train enters the loop and then before it fully traverse it, the points need to be set the other way. However, polarity of the loop must stay the same while the train is traversing it, otherwise the locomotive would abruptly reverse direction, with dire consequences.

This presents a problem of timing, in coordinating the switching of track polarity with pointing changeover.

In DCC systems, the problem is slightly different because the direction of the locomotive and train is not affected by track polarity; it is controlled by the DCC data.

However, the problem of the short circuit in the loop still remains, so the track polarity still has to be changed. Unfortunately, humans will not be quick enough to toggle the switch at the precise moment needed to prevent a short occurring.

That is of course, even if we remember to toggle the switch as the train travels round the loop!

That is where this project comes to the rescue. Instead of avoiding the occurrence of the short as the locomotive bridges the gaps in the tracks, it senses the inevitable short-circuit current and then switches the track polarity to avoid it.

This then avoids the nasty situation when a momentary short in the loop is enough to shut down the entire DCC layout, as the base station or DCC

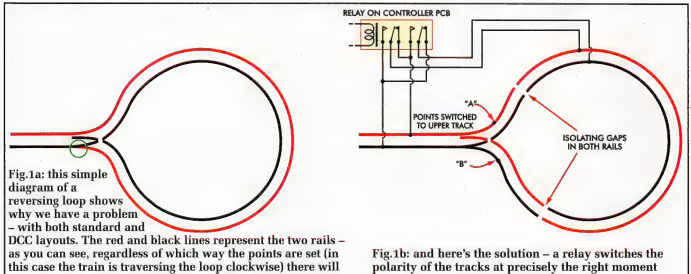


Fig.1a: this simple diagram of a reversing loop shows why we have a problem – with both standard and DCC layouts. The red and black lines represent the two rails – as you can see, regardless of which way the points are set (in this case the train is traversing the loop clockwise) there will always be a short circuit between two of the tracks (shown here with the green circle). In real life, this doesn't matter – but for model railroaders, where the tracks supply the loco power, it is a serious problem!

Fig.1b: and here's the solution – a relay switches the polarity of the tracks at precisely the right moment so that the short is eliminated. This arrangement would not work for standard (DC) tracks (the train would go backwards) but is perfect for DCC layouts. A microcontroller takes care of the timing.

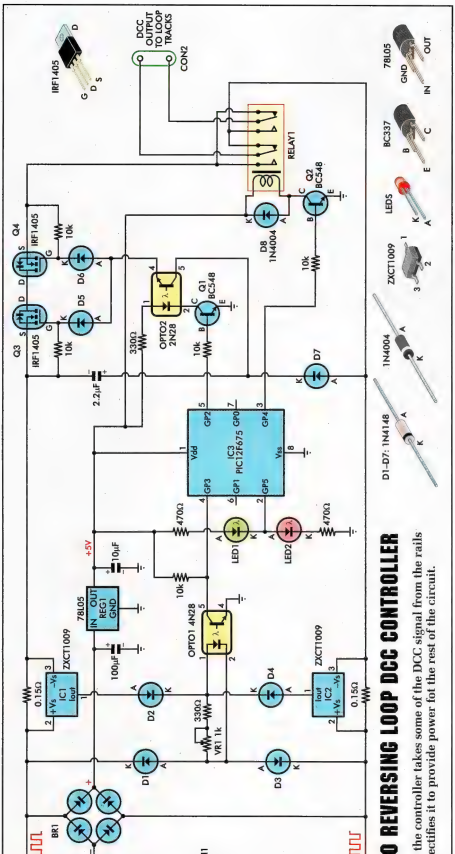


Fig.2: the controller takes some of the DCC signal from the rails and rectifies it to provide power for the rest of the circuit.

booster current limit is exceeded.

Our automatic reverse loop controller performs the above procedure automatically.

The train and the operator is not even aware that the polarity has been changed. All anyone might notice is the train entering the loop using points (or turnout in US model railroad parlance), travelling round the loop then exiting the loop using the same set of points.

In fact, the only indication that the track polarity was changed is that the on-board LEDs on the auto controller will toggle.

All the operator has to do is to remember to change the points after the train has entered the loop. Even this task can be automated but that's a story for another time.

How does it work?

As with many circuits these days, this device is under the control of a small microcontroller, a PIC12F675. It constantly looks for the short circuit current that is caused whenever the locomotive's drive wheels bridge the isolating gap in the rails.

The track current is sensed by two Zetex ZXCT1009 high-side current monitors. These surface mounted devices each monitor the voltage across an associated 0.15Ω shunt resistor and convert this voltage to a current.

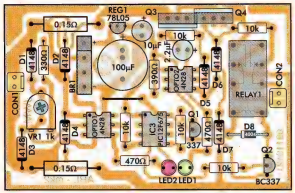
We need to sense currents of either polarity and that is why two such sensors are required.

The output currents of both sensors are fed via diodes D2 & D4, trimpot VR1 and a 330Ω resistor to the junction of diodes D1 & D3 and these four diodes act as a bridge rectifier for the sensor output currents.

If a short circuit does occur, the resulting voltage across trimpot VR1 and the 330Ω resistor will be sufficient to turn on the infrared LED inside optocoupler OPTO1. This will pull the GP3 input, pin 4, of the PIC controller low.

As soon as this happens, the micro switches off the DCC signal then toggles the relay so that the polarity to the loop is now reversed.

A delay of 20 milliseconds allows the relay contacts to move before the DCC signal is switched back on. Hence the track polarity is reversed and the train has continued along on its merry way all in the space of 20ms; much quicker than we humans could do the job.


REG1
78L05
Q3
Q4
0.15Ω
10k
0µF
2.2µF
100µF
3300µ
D7
4148
4148
4148

An alternative use for the Auto Reverse Loop Controller

Another very useful project for use on DCC layouts is a Block Overload Switch.

This allows the output of your booster to be divided up into however many sections you want.

As an example, say you have a shunting yard and a main line runs through or along the edge of this yard. Your booster would be powering both the main line and the yard.

This is not an ideal situation. A derailment or other problem causing a short circuit will shut down the yard as well as the main line.

To overcome this problem you might want to isolate the yard from the main line then power each with their own booster. This way a short in the yard will allow the main line to operator unimpeded.

However, two boosters is an expensive option.

Enter the Block Overload Switch

This item will take the output of any booster and divide it up into isolated channels. If we connect the yard to the main line booster via a block switch, any fault in the yard will now only shut down the yard and not the main line.

The Auto Reverse Loop project presented here can easily be converted into a Block Switch with a few simply modifications.

The relay is left out and a new program is loaded into the microcontroller.

Upon detection of a short circuit, the reverse loop program switches the DCC signal off then toggles the relay before switching the DCC signal back on.

The new version of the software eliminates that step and simply switches off the DCC signal for four seconds. The extra time is needed because it is not a good idea to switch power off to a sound-fitted loco then almost immediately back on again. The 4s delay makes sound decoders much happier.

How many Block Switches?

In theory there is no limit to the number of Block Switches that can be connected to a booster. However, a good rule to follow is to divide the output current of the booster by the trip current of the block switch.

For example, your booster is a 10A job. Each block switch trips at 2A. 10 divided by 2 equals 5. This would mean you would use four block switches with a 10A booster.

Is that right, did I not just calculate 5 block switches? Yes, but there is no error.

Remember that the booster is powering our main line as well, so this counts as output channel one.

The relay is controlled by transistor Q2 which is switched by the micro from its GP4 output at pin 3.

That's really all there is to the circuit apart from the use of the 78L05 3-terminal regulator, REG1, which in conjunction with the bridge rectifier BR1 is used to produce a 5V DC rail for the microcontroller.

Putting it together

The entire circuit is accommodated on a small PCB measuring 75 x 48mm and coded 09110121. Assembly is straightforward except for the two ZXCT1009 surface mount current monitors. These should be soldered onto the underside of the PCB before any other components are installed.

Many constructors are scared off when a project uses SMDs but (a) you shouldn't be – they're not that hard to solder, especially if you follow a few simple rules and (b) you'd better get used to them or your project building days could be over. Many components are now only available in SMD packages and that's likely to increase in future.

Use a temperature-regulated iron with a fine chisel or conical point, well wetted with solder. Hold the PCB steady and carefully hold the device you want to solder in position with, say, a toothpick or similar non-solderable and heat-insulating "tool".

Tack solder a couple of opposite pins to hold the device in place while you solder the rest of the pins (in this case there are only three pins total). Make sure your original tack-soldered pins are properly soldered and don't worry if you accidentally solder a bridge between pins – these are almost inevitable and can be removed, one side at a time, with solder wick.

Finally, check your soldered component under a (preferably illuminated) magnifying glass to ensure there are no bridges or dry joints.

Once satisfied, turn the board over and solder the top-side components in the normal way – just be mindful that some components also solder to the same pads as the underside SMDs.

The resistors can go in first, followed by the eight diodes. IC sockets are recommended for the micro and maybe the opto-couplers.

The remaining components can now be installed, leaving the relay and large electro until last (they get in the way when soldering smaller components). Take care with the orientation of the diodes and electrolytic capacitors. The single link can be made from a resistor lead offcut.

At this stage you will be ready to connect power. At first leave out the microcontroller.

Wire the system to the output of your DCC command station or booster. Switch on and look for the tell-tale signs of the infamous escaping blue smoke.

Resistor Colour Codes

No.	Value	4-Band Code (5%)	5-Band Code (1%)
☐ 5	10kΩ	brown black orange gold	brown black black red brown
☐ 2	470Ω	yellow violet brown gold	yellow violet black black brown
☐ 1	390Ω	orange white brown gold	orange white black black brown
☐ 1	330Ω	orange orange brown gold	orange orange black black brown
☐ 2	0.15Ω 3W	not applicable	not applicable

If all appears OK, measure the voltage across pins 1 and 8 of the micro socket with your DMM. You should read close to 5V DC. If so, switch off, leave a few seconds or so then insert the microcontroller (make sure you get it the right way around!).

Switch on again. This time the LEDs should toggle a couple of times and after this the DCC signal should appear at the output terminals.

This can be verified by wiring the output to a piece of track and trying to control a locomotive using your DCC controller. Or you can just connect it to your reverse loop and again try controlling a train.

A multimeter set to AC volts can also be used to detect the DCC signal. Note that this will not be an accurate reading but is simply an indication that the DCC signal is passed to the output terminals.

The next step is to see if the unit will swap the output. Remove any locos from the loop and using a short piece of wire, quickly short out the track – touch the wire to the tracks then remove it again. If you do this within about 50ms (that's pretty quick!) the relay should toggle. If you take longer then the relay should toggle but the DCC signal will drop off for one second.

Now place a loco on the loop and start it moving. Do the short circuit trick again with the short length of wire. If you are quick enough the loco should continue on without stopping. The final test is to see what happens as the loco crosses the gaps in the reverse loop.

Remember here that if the polarity is the same on both sides of the gaps, nothing will happen.

At some point however one of the gaps will have opposite polarities and this is where you will see the action of the system.

If all is OK then that is it. You can install the unit permanently under the layout. Once operational there is no maintenance required.

Adjusting the current limit

The onboard trimpot is used to set the trip point current level. In most case you can just leave the trimpot centered. This will give about 2A before the unit toggles.

If you really want to set the level then the best way is to simply and progressively connect a bunch of 5W resistors across the track to build up the load on the unit.

The load current can be monitored at the DC input to the booster or DCC system. Using a multimeter set to the 10A range, connect it in series with the DC power supply to either your DCC system or Booster.

With no load on the reverse loop take a reading of the current being drawn by the DCC system or booster and note it down.

Now, using 15 to 30Ω 5W resistors, connect one at a time across the reverse loop tracks. Depending on the voltage level from your booster or DCC system each resistor will increase the current by a certain amount.

Start with some 30-odd ohm resistors. Each one will draw around 500mA or so. Keep monitoring the multimeter and when the load current has increased by the amount you want your reverse loop unit to trip at, adjust the trimpot so that the unit triggers.

Let the system go through its 1s off time then see if the power switches on and then off again almost immediately. If so then you have set your unit to your desired trip current. SC

SERVICEMAN'S LOG

Back up your data or risk losing it!

Ever had that sinking feeling when a hard disk drives fails and you haven't backed up critical data? Or have you accidentally deleted one or more important files? Retrieving your data depends on the nature of the problem and the experience of the person doing the recovery.

Items Covered This Month

- Recovering data from a hard disk drive
- DAB+ Tuner Fault
- Onix DVD-681 DVD player

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

ONE OF THE unforeseen side-effects of the quakes here in Christchurch has been a sharp increase in the number of failing computer hard drives turning up at my workshop. Losing a hard drive to the data gods is bad enough in its own right but having one fail on top of everything else that's been happening here lately can be a particularly bitter pill to swallow.

There's nothing new in this. I've been harping on in my client newsletters for years now about the importance of backing stuff up. However, the sad fact is that many people don't do this, either because they don't know how or because they think that catastrophic data loss only happens to other people. In fact, some PC users aren't even aware that their drives can fail and blithely go on assuming that the hardware lasts forever.

My advice to such people is very simple. If you'd be in deep water if your hard drive failed right now and you don't know how to back up, then you should ask a computer professional for advice – and soon. The truth is, backing up needn't be complicated nor expensive.

So what exactly is a hard drive? Some people mistakenly call everything that's inside their computer's case "the hard drive", as in: "should I bring in just the hard drive or do you want the keyboard as well?"

In practice, of course, a hard drive is a fixed storage disk. Inside the sealed metal case of the drive, a precisely-controlled head skims just above the surface of one or more highly-polished spinning disks (platters), reading and writing binary data in the form of magnetically-encoded 1s and 0s.

Think of an old record player but substitute a small steel disk for the plastic record and replace the tone arm with the read/write head and you'll get the basic idea. In fact, it's worth hitting YouTube to watch one running with the covers off.

The wonder is that hard drives last as long as they do, given the amount of work they do. However, the laws of physics do catch up eventually. All moving parts gradually wear out and hard drives are no different. I put the average life of a desktop drive at about three years, with laptop units a little less. The mileage varies greatly though; I've seen drives fail within days while others last more than 10 years

But regardless of averages, it's really a matter of "when" rather than "if" when it comes to drive failure – or at least, that's my philosophy. And when it does, if your data isn't backed up, then some form of data recovery will be necessary if you really must retrieve critical files.

The problem is, data recovery isn't always guaranteed to work, or it may be only partially successful. Data recovery is a complex and all-too-often fruitless process, where success seems to be inversely proportional to the importance of the data to be recovered.

Indeed "Murphy's Law of Backing Up" dictates that when a drive fails, nothing wanted from it has been backed up (or it was going to be backed up tomorrow) and only junk or easily-replaceable files will be recoverable. Improbable depictions of data recovery in TV shows, brothers-in-law who "know all about computers" and thousands of ill-informed Internet forum posts on the subject mean client expectations are often unrealistic, with many believing recovery to be a simple process. The reality is somewhat different.

Hard disks fail in different ways and how a repair agent deals with these different failures is what separates the men from the cowboys. Anyone can download data recovery software from the net and set themselves up in the data recovery business but merely

A Tricky Fault In The DAB+ Tuner

A temperature-sensitive dry joint can be difficult to track down, especially on a board involving surface-mount parts. D. P. of Faulconbridge, NSW was recently confronted with just this type of problem in the Venice 7 RF module of his SILICON CHIP DAB+ Tuner. Here's his story . . .

In January this year, I built the SILICON CHIP High-Quality DAB+/FM tuner from a Jaycar kit. All went well and the receiver worked from first switch-on. It initially had a few odd operational characteristics but these were all resolved when I updated the firmware, as recommended in the constructional article.

It proved to be a very nice receiver indeed. In fact, I soon came to the conclusion that those contributors to the SILICON CHIP Mailbag who complain about the audio quality of DAB+ must be very hard to please indeed. Or maybe they're not listening with the SILICON CHIP receiver!

Anyway, it all worked beautifully for several months and then suddenly some very unpleasant distortion began to be heard intermittently on DAB+ only. This distortion was generally present at switch-on but would then gradually fade away over the next few minutes.

The distortion sounded like some kind of RF interference. It manifested itself as a kind of cyclic, crackling noise, as though it was coming from something like a motor commutator. The only problem was that there were no motors running nearby when the interference was in evidence.

At first, this "interference" or distortion wasn't really a problem because it only lasted for a few minutes, after which the receiver performed perfectly. But as time went by it got worse, both in intensity and duration, until eventually the interference didn't go away and made DAB+ completely unlistenable.

Forced to think more carefully about the problem now, I realised that the fault had been getting worse as winter approached so it was probably temperature-related. As a result, I placed the receiver outside in the cold Blue Mountains morning air for half an hour one morning, then brought it back inside and switched it on. This left me in no doubt that I had a temperature-sensitive fault because the "interference" was now so severe that there was no recognisable program output at all.

I quickly opened up the case and armed with my wife's hair-drier, began warming various parts of the circuit board. Nothing changed until I got to the Venice 7 RF module which is the heart of the receiver. As soon as the warm air was directed towards this module, the interference rapidly faded and was replaced by clean audio. The tiniest blast of freezer spray on the Venice 7 module then immediately brought the interference back again.

That was rather nasty! I had been hoping to find a bad solder joint on the main PCB, which would be easy to fix. A fault in such an arcane piece of gear as the Venice 7 module was another matter altogether!

Deciding that there was nothing for it but to bite the bullet, I carefully levered the little tin-plate cover off the Venice 7 module. This revealed a small circuit board containing several tiny surface-mount ICs and a sprinkling of other surface-mount parts marked with microscopic numbers that meant nothing to me.

A few blasts of freezer spray through a fine tube soon isolated the problem to one particular part. I then found that the fault could be made to come and go by gently prodding this item with an insulated alignment tool. Even with plenty of light and my most powerful magnifying glass, the soldering on this component looked OK, so it was possible that the component itself was faulty. However, I though that I would try resoldering it first.

With the finest tip on my soldering iron and a tiny dab of flux on each end of the component, I quickly melted the solder at each end. And that was it! The receiver is now completely reliable in any weather! Apparently even modern automatic soldering methods are not foolproof and can still produce the oldest problem in the electronic servicing book – the dry joint.

possessing such software tools doesn't make someone an expert.

Bread & butter

A typical bread-and-butter recovery task would be where a client has deleted one or more files and wants to retrieve them. In this case, provided that the drive itself is working fine, almost anyone with basic computer knowledge and a little research can undelete a file, even if it has been "emptied" from the Windows Recycle Bin.

However, if the target drive has been formatted, a process that makes the drive appear "empty" to the operating system, then things get a little tougher. Even then, recovery is still a relatively simple procedure provided that the drive hasn't been overwritten.

And here a brief word about formatting. Many people believe formatting a hard drive "wipes" the data from it. It doesn't; in basic terms, formatting simply overwrites or blanks the drive's file "index", which is why Windows thinks the drive has nothing on it.

Fortunately, when it comes to data recovery, formatting leaves any existing data relatively untouched. By way of analogy, if you tear the index out of a book, information in the rest of the pages might be harder to find but it is still there.

Because Windows relies on the hard drive's index to know where your files are, a blank index leads Windows to assume that the drive is empty and that data can be written to the free space. However, there are various utilities than can "un-format" a drive and provided nothing else has been written to the drive in the meantime, it's all very straightforward.

Conversely, if new files have been written over any of the old data, then recovering that data becomes much more difficult.

Partitioning

Drives can also be partitioned, which means that the storage area on the disk is split into separate compartments (or partitions), usually with a different drive letter assigned to each one. Most Windows installations have at

least one partition, with later operating systems having at least two (one being a small area set aside for operating system files).

During partitioning, the partition information is written to a special area of the drive and losing that information through mechanical failure, a virus infection or accidental repartitioning usually results in data loss. However, even if partitions have been altered or deleted, specialised software can often still make enough sense of the drive's mangled contents to allow certain files to be recovered.

This level of recovery is about as far as many computer shops go, usually because the specialised gear that allows for more in-depth recovery requires a significant financial outlay. And that's something smaller shop owners have to weigh against the amount of data recovery work they are likely to be asked to do. It's a matter as to whether the returns from such specialised work are going to make the investment worthwhile.

This is also the reason that advanced data recovery jobs usually cost a lot more.

Broadly speaking then, there are two distinct groups when it comes to data recovery: (1) the professional recovery houses whose fees are typically very high but which usually get results, even for difficult jobs; and (2) the smaller shops whose experience and abilities vary greatly. Unfortunately there isn't much in between, which isn't exactly ideal for those seeking to have files recovered.

In my experience, people making enquiries about data recovery usually have a specific file or files in mind, be it music, family photos or accounting data. They also usually want to know how much it's going to cost and this is a tough question to answer before undertaking some basic checks.

In our case, we always check the drive out before giving an estimate. If the drive is not spinning or is no longer detected by the computer's BIOS, successful recovery depends greatly on the likelihood of the recovery agent having an identical working drive and the facilities to swap out the guts of the drive. We don't have the necessary gear for this, so we have to pass on such recovery jobs.

Conversely, if the drive still powers up and the computer's BIOS detects it, recovery at our level of expertise is well within reach. So a drive reaching us in this condition is regarded as an excellent candidate for recovery.

It all depends . . .

Having said all that, successful data recovery ultimately depends on the physical state of the target drive, regardless as to how much a client is willing to pay. For example, if the read/write head has touched and marked the platters, no amount of money, fancy hardware or technical jiggerypokery is going to recover the data under that scratch.

As a general rule, if the platters are marked or otherwise damaged, recovery is usually impossible.

So receiving drives in a reasonable condition is a big deal for data recovery servicemen. However, it sometimes happens we get the drive only after the owner or their friends "have had a go" at it themselves and while this is quite natural and well-intentioned, it often does far more harm than good. The same can be said for inexperienced technicians or other parties who figure that they haven't anything to lose by diving in because the drive is already "dead". Little do they realise that they could well be throwing away the only viable window of opportunity to recover any data.

Urban legends

If a hard drive is failing, its life expectancy can sometimes be measured in hours, if not minutes. This is sometimes not long enough to enable data recovery using basic methods, even for those who know what they're doing.

In desperation, many people resort to old-wives' tales and urban legends, like putting drives in the freezer or an oven overnight, or waving magnets over them, or lightly tapping them with a hammer and so on. Well, it won't surprise you to learn that these methods do not typically get non-working hard drives working again.

Of course, it seems that everyone has heard how someone's friend's brother's nephew put his drive in the freezer and "it worked!" But while this nonsense makes great forum fodder, it's highly unlikely that any of the above methods will result in a working drive, let alone successful data recovery.

So what are your options if you want to retrieve critical data from a suspect drive? Well, your best bet is to immediately power it down, resist the temptation to have a go at it yourself (or let your mate who reckons he knows how) and seek professional advice.

High-end data recovery houses usually charge a fixed fee to assess the drive and then so much per megabyte of data recovered. They are few and far between so you'll likely have to ship the drive to them. They usually give clear instructions on how to package the drive so that it arrives in good condition and once received, they'll assess it and report back on the feasibility and probable costs of recovery.

Many vendors like this will still charge a fee regardless of the outcome and this is acceptable industry practice; after all, they are still using their time, knowledge, expertise and equipment regardless of the outcome.

Note too that due to the size of hard drives these days and the amount of data on them, data recovery costs can run into many hundreds of dollars.

The equipment used

Some specialists seem happy to perpetuate the myth of expensive equipment operated by forensic-suited engineers in laboratory-style cleanrooms but the reality is usually a bit

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

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less glamorous. While a job like a platter swap must be done in a dust-free environment, an entire clean room isn't necessary. A standard table-top dust-free cabinet does the job nicely. And as for all their mysterious hardware, various specialised jigs are used but they are readily obtainable. The main problem is that one jig usually covers only one drive model, meaning a large number of jigs are needed for doing multiple drive types and the costs soon mount up.

In addition, specialised hardware and software is sometimes used to rewrite lost EPROM data on the drive's control board. Again, this type of gear can be purchased by anyone, though it can cost upwards of a few thousand dollars.

The biggest asset professional data recovery houses possess is their store of hard drives – basically, one or more of every make and model available. Having an identical, known-working model of any given hard drive gives them the ability to carry out circuit board and platter swaps, meaning even dead drives can be resurrected.

If you don't want to spend hundreds on data recovery, your only option is to approach a local repair shop. Not all computer repair outfits offer data recovery so you might have to ask around for those who do.

Smaller shops may not have the resources of the big outfits but they can still handle a wide variety of data recovery jobs. Don't be afraid to ask the shop about previous recovery experience and avoid places that simply volunteer to "give it a go". While some vendors offer "no fix, no fee" deals, others charge a flat fee or may require a deposit regardless of outcome. Cheapest isn't necessarily the best, so trust your instincts.

How sick is the drive?

So how do you know what level of repair your sick drive needs? If your drive isn't spinning, gets hot or is making loud noises (the dreaded "click of death), a professional firmware or platter swap (or both) is required. If your drive is spinning and sounding normal and the computer's BIOS detects it but Windows doesn't, chances are your local data recovery serviceman should be able to help. Your safest bet is to take it to your computer serviceman and ask them. Be careful though – drives are not only fragile but are static-sensitive as well, so place it in an anti-static bag for transport.

Can you do the job yourself? After all, internet forums have lots of information on data recovery and there are plenty of online videos demonstrating platter and firmware swaps.

Well, maybe and maybe not. Let's look at a few scenarios. First, let's assume that your drive spins and that the computer's BIOS detects it but Windows cannot mount it. If you have a second computer to mount the target drive in and software like Ontrack's Easy Recovery or R-Tools Technology's R-Studio, you should be able to access the data. However, it's worth noting that some forensic-level recovery software can cost much more than a computer technician would charge to recover the data.

If your drive doesn't spin at all, then things start to get serious. Hard drives have four major components: the motor, platters, read/write head and control board. A control board swap is the easiest because it is on the outside of the drive and only held on by half a dozen screws. However, the donor drive must be identical in every respect, right down to the firmware revision and model numbers. If they differ in any respect, you'll be wasting your time.

Having said that, control board swaps almost never work. Out of the hundreds I have done, only a handful resulted in a spinning drive.

If it isn't the control electronics, then either the motor, head or platters must be at fault and the only way around that is a platter swap. You will need to pull the platters from both drives and mount the ones from your dead drive in the good drive. It sounds easy but even with the custom jigs and tools now available, it is a process fraught with potential disaster.

If your drive has more than one platter (most do), they must stay exactly aligned or all is lost. If you touch the platters or head or get dust anywhere near any of the components, it is game over.

Finally, even if you manage to swap everything out successfully, there is still no guarantee the drive will power

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up or you will be able to recover data, which is why data recovery on a dead drive is usually best left to the professionals.

Onix DVD player

DVD players are now so cheap that repairs are generally uneconomic, unless the labour comes free. A. P. of Toowoomba, Qld recently gave an Onix DVD player a new lease of life . . .

My friend Nick brought me his Onix DVD player (model DVD-681) which had stopped working. I turned it on and there was no light or sound.

As I picked up a Philips screwdriver, I told him that the repair was just about to become uneconomic, since DVD players are now so cheap. I unscrewed the six machine screws that held the cover on and slid it off.

Inside, the circuitry was contained on two main boards. One of these carried some large surface-mount chips and was obviously the signal processing and control board, while the other was the switchmode power supply board.

My attention was immediately drawn to the bulging top of a 47µF 400V electrolytic capacitor on the power supply board. Next to this capacitor was an MJE13005 transistor bolted to a small aluminium-extrusion heatsink. My DMM showed that this transistor was almost a dead short between all terminals.

At this point, I advised Nick to simply buy another DVD player. I still planned to repair the existing player but I didn't have the parts in stock and I wanted to wait to accumulate a reasonable parts order for other repairs to save on postage costs. And even when I had replaced the parts, there was no guarantee that other parts hadn't failed.

A few weeks later, I ordered the necessary parts from an overseas supplier and waited. And waited and waited and waited. I had heard that this supplier could be slow but after waiting two months, I emailed them to ask what had happened to my order. The email bounced so I tried their website and it was gone.

At that point, I assumed that the supplier had gone bust. However, a few weeks later, I noticed that they were being mentioned favourably in an on-line forum so I again tried their website. This time, it was there and after further investigation, I discovered that I had mis-typed the URL the first time!

Anyway, I tracked down the confirmation email from the original order and was able to use the order number to log in and check the order status. It was still on their system but didn't seem to be progressing. I found a contact link and enquired as to why it was taking so long.

It turned out that my order was being delayed while they waited for a component unrelated to the DVD repair to become available. As a result, I authorised the supplier to send the order without this component and two weeks later I finally had the parts I needed.

When I replaced the capacitor and the transistor, I discovered that the old capacitor wasn't just low in value but wouldn't even give a reading on my Peak ESR meter. Also, now that I could see the old transistor closely, it had a crack from top to bottom.

The original transistor had a metal tab while the replacement was all plastic. There was no heatsink compound between the original transistor and its heatsink, which may have contributed to its failure. As a result, I smeared heatsink compound on the back of the replacement transistor, just to be sure that it wouldn't overheat.

Initially, I decided to test the power supply unloaded. Donning my goggles in case the capacitor exploded, I switched on and measured the power supply's output voltages. They were all zero.

It was then that I noticed a black oblong component on the power supply board. Could this be a standby relay that was preventing the power supply from operating without the remaining circuitry plugged in?

Closer inspection revealed that it wasn't a relay but a fuseholder for a 2AG glass fuse. I unclipped the lid, removed the fuse and found that it was open circuit. I couldn't make out its rating but based on the 25W (max.) nameplate rating of the player, I decided that a 125mA slow-blow fuse would be suitable.

This time, when I powered the unit up without anything connected to the power supply, I could hear a ticking sound (a bit faster than once per second). I wasn't sure if this meant that something was under stress, so I hastily measured the 5V rail before switching off. It was 5.12V and that was good enough for me to suspect that the power supply was now working properly.

Next, I reconnected the main board to the power supply and switched it on again. The unit was now operating normally. The ticking sound was gone and the fluorescent display gave the correct readouts as I opened and closed the disc tray and played a DVD.

So job done. The only remaining task is to ask Nick if he still has the remote control. SC

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XC-4691

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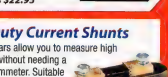

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Refer: Silicon Chip Magazine July 2012

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Refer: Silicon Chip Magazine August 2012

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- Handles loads up to 5A
- PCB: 60 x 76mm

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Refer: Silicon Chip Magazine June 2012

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WQ-7241	Lead Video Scart to 3RCA Component 5m	$59.95	$49.95	$10.00
CG-2381	Speaker PA Paper Cone 10"	$99.00	$69.00	$30.00
AC-1613	Splitter 2Way Toslink Digital	$69.95	$59.95	$10.00
CX-2685	Sub-woofer Port Adjustable Angled 84mm Dia.	$19.95	$9.95	$10.00
AR-1824	Transmitter and Coupler - IR Over Coax	$29.95	$14.95	$15.00
CT-2023	Tweeter Ribbon 100mm - BARGAIN	$29.95	$24.95	$5.00
CW-2802	Wall Bracket for Top Hat Mount PA Speaker Adjustable	$24.95	$19.95	$5.00
LT-3037	Wall Plate Audio/Video Balun	$69.95	$29.95	$40.00
PS-0289	Wall Plate with HDMI Flylead White	$24.95	$14.95	$10.00

USB Cassette Deck with Audio Out

Original RRP $79.95
Special Price $49.95
Save $30.00
GE-4054

Auto & Outdoors Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
WH-3060	Cable Power 8 GA OFC Red	$3.60	$3.00	$0.60
WH-3059	Cable Power Supra 8 GA OFC Tin Plated Black	$3.50	$2.00	$1.50
LA-9030	Car Alarm Microwave Sensor	$34.95	$19.95	$15.00
AX-3580	Car Speaker Spacer 6" Twin Pack	$9.95	$7.95	$2.00
SF-1946	Fuse Maxi Gold 60A Pk2	$8.95	$4.95	$4.00
SF-1948	Fuse Maxi Gold 80A Pk2	$8.95	$4.95	$4.00

5" Car Speaker Splits VIFA

Original RRP $179.00
Special Price $159.00
Save $20.00
CS-2398

Gifts & Gadgets

Cat No.	Product Description	Original RRP	Special Price	SAVE
KT-2550	Ethanol Bio Fuel Energy Kit	$199.00	$50.00	$149.00
GH-1898	Hub USB 4Port with Pink Rhinestones	$29.95	$14.95	$15.00
QM-3779	Photo Frame 3.5" LCD	$59.95	$29.95	$30.00
GT-3756	Race Car Solar Green SUV	$12.95	$9.95	$3.00
GT-3755	Race Car Solar Red	$12.95	$9.95	$3.00
GH-1894	Stapler with Pink Rhinestones	$19.95	$9.95	$10.00
TD-2075	Tool Set 149-Pce Pink	$49.95	$34.95	$15.00
GT-3752	Wind Generator with LED Illumination Mini	$19.95	$9.95	$10.00

3MP Mini Digital camera

Original RRP $29.95
Special Price $24.95
Save $5.00
QC-3196

Books

Cat No.	Product Description	Original RRP	Special Price	SAVE
BT-1372	AVR An Introductory Course	$119.00	$105.00	$14.00
BI-8208	Installing a Car Alarm or Immobiliser	$2.00	$1.80	$0.20
BI-8207	Installing A Sound System In Your Car	$2.00	$1.80	$0.20
BT-1367	PIC Robotics - A Beginner's Guide	$59.95	$53.00	$6.95
BT-1365	Robot Builder's Sourcebook	$59.95	$53.00	$6.95
BJ-6025	TV/Video Resolution Chart	$9.95	$8.00	$1.95

Hardcore Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
HB-6600	Carry case for CRO HPS10	$39.95	$19.95	$20.00
NS-3050	Chip Quik SMD Removal Kit	$39.95	$29.95	$10.00
PT-4912	Connector QC Chassis Spade 6.4mm Pk100	$19.95	$14.95	$5.00
NS-3042	Desoldering Braid Dispenser Gun	$79.95	$44.95	$35.00
HB-6410	Enclosure ABS IP66 Small - Clear Cover	$18.95	$12.95	$6.00
ZM-9080	Fuel Cell Module 300mW	$99.00	$30.00	$69.00
PI-6491	IC Socket 8Pin Wire Wrap	$2.95	$1.95	$1.00
ZL-3602	IC TDA1905 DIP16 5W Pk10	$19.95	$14.95	$5.00
ZD-1739	LED 3mm Bicolour Red/Green	$0.73	$0.25	$0.48
ZD-0199	LED 5mm Pink 2000MCD	$5.95	$1.95	$4.00
AA-0590	LED Driver Power Supply 3V In - 350mAh Out	$15.95	$9.95	$6.00
ZD-0304	LED Globe 6V Mini Edison 12 x White	$26.95	$14.95	$12.00
ZD-0300	LED Globe 6V Mini Edison 6 x White	$24.95	$4.00	$20.95
ZD-0454	LED Light Bar Module 12VDC White	$14.95	$9.95	$5.00
ZD-0444	LED Star Module XR-E Warm White	$27.95	$12.95	$15.00
ZD-0442	LED Star Module XR-E White	$27.95	$12.95	$15.00
AR-3278	Lightning Protector for 2.4GHz N	$89.95	$24.95	$65.00
LM-1654	Magnet Super Strong Horseshoe	$39.95	$24.95	$15.00
PP-1072	Plug Amphenol XLR/5P	$17.95	$6.95	$11.00
HG-9985	Pressboard insulation Material	$4.95	$3.95	$1.00
YG-2868	Pulley Set Small	$12.95	$9.95	$3.00
SY-4042	Relay Panel Mount SPST 12V	$6.95	$4.95	$2.00
ZV-1612	SMD V Regulator LM317LMX 100mA +ADJ SOIC8 Pk10	$24.95	$19.95	$5.00
ZV-1545	SMD V Regulator MC78L05 100mA +5V SOIC8 Pk10	$14.95	$9.95	$5.00
ZV-1546	SMD V Regulator MC78L08 100mA +8V SOIC8 Pk10	$14.95	$9.95	$5.00
ZV-1548	SMD V Regulator MC78L12 100mA +12V SOIC8 Pk10	$14.95	$9.95	$5.00
ZV-1544	SMD V Regulator MC78M05 100mA +5V DPAK Pk10	$14.95	$9.95	$5.00
ZV-1552	SMD V Regulator MC78M15CDT 100mA +15V DPAK Pk10	$24.95	$19.95	$5.00
ZV-1550	SMD V Regulator MC79L12 100mA -12V SOIC8 Pk10	$14.95	$9.95	$5.00
ZV-1583	SMD V Regulator SMCLM317MT D2S2AA ADJ Pk10	$24.95	$19.95	$5.00
PS-1076	Socket Amphenol XLR/5P	$24.95	$9.95	$15.00
SS-0825	Switch Slide Illum SPDT LED Red	$4.95	$3.95	$1.00
SP-0752	Switch Toggle Illum SPDT 12V	$22.95	$14.95	$8.00
AA-0212	Switcher Master/Slave 230V	$36.95	$29.95	$7.00
MM-2026	Transformer 37.5-0-37.5 2.5A Centre Tapped 175VA	$64.95	$44.95	$20.00
ZZ-8820	Wafer Card Emerald	$14.95	$8.00	$6.95
ZZ-8810	Wafer Card Silver	$19.95	$8.00	$11.95
NA-1025	Water Displacer & Lube Spray 175g	$5.95	$3.95	$2.00

12V Sleeve Bearing Blower Fan

Original RRP $17.95
Special Price $12.95
Save $5.00
YX-2530

Kit Back Catalogue

A list of kits only available from Techstore. Full list can be found on our website. Just search for "kit back catalogue".

Cat No.	Product Description	PRICE
KC-5468	Balanced to Unbalanced Audio Converter Kit	$32.95
KC-5479	Battery Zapper Mk III Kit	$79.95
KC-5469	Bridge Mode Adaptor for Stereo Amplifiers Kit	$27.95
KC-5456	Emergency 12V Lighting Controller Kit	$69.95
KC-5379	High Performance Timer Kit	$42.95
KC-5493	Low Capacitance Adaptor for DMM Kit	$34.95
KC-5468	Marine Engine Speed Equaliser Kit	$39.95
KC-5457	PIC Logic Probe Kit	$16.95
KC-5455	PIR Controlled Mains Power Switch Kit	$79.95
KC-5458	Rolling Code Infrared Keyless Entry System Kit	$64.95
KC-5472	School Zone Speed Alert Kit	$49.95
KC-5481	SD Card Speech Recorder/Player Kit	$74.95
KC-5374	Smart Fuel Mixture Display for Fuel injected Cars Kit	$29.95
KC-5487	Stereo Digital to Analogue Converter Kit	$139.00
KC-5483	UHF Rolling Code Remote Switch Kit	$99.95
KC-5484	UHF Rolling Code Transimtter for KC-5483 Kit	$39.95
KC-5470	Ultra-Low Distortion 135WRMS Amplifier Module Kit	$94.95
KC-9128	VHF Converter Kit 100-200MHz	$29.95
KC-5490	Voltage Modifier Kit	$79.95
KC-5486	Wideband Fuel Mixture Controller Kit	$79.95

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/10/2012.

GREAT AUTO & OUTDOORS SAVINGS

12V Car MP3 Player

An MP3 player that plugs directly into your cigarette lighter socket. It transmit audio playback from an SD card, USB Flash disk or any external audio source to any frequency in the FM band of your car stereo. Steering wheel mounted IR remote included.

- Sizes: 70(H) x 50(W) x 22(D)mm

AR-1865 ***was $34.95***

$24.95 SAVE $10

7" TFT Colour Monitor with Headrest & DVD Player

This system not only plays DVDs, but also your video files such as DivX, MPEG4, etc. from DVD, USB stick or SD card. You can also connect an Xbox360® or Playstation3® via the AV input. Includes an in-built games system (games CDs included), two games controllers and IR remote control.

- Resolution: 1440 x 234 (16:9/4:3 selectable)
- Power: 12VDC
- Dark grey leather-look upholstery
- Supports infrared earphones
- Headrest size: 280(W) x 200(H) x 110(D)mm

QM-3776

$199.00

BUY BOTH FOR $299 SAVE $39

7" TFT Colour Monitor with Headrest

If you already have a DVD player or other video source in the car you can set this up as an extra monitor for a complete in-car video entertainment system. Features a 7" TFT screen, two composite video inputs and IR remote control and is identical in appearance to the QM-3776 above making them an excellent "pair".

QM-3766

$139.00

185 Lumen CREE® LED Head Torch

A powerful head torch for work in dark places or when you're out in the wilderness. It outputs 185 lumens of white light and features an adjustable head strap.

- Burn time: 8hrs
- Water resistant
- Requires 2 x AA Batteries

ST-3283 ***was $39.95***

$29.95 SAVE $10

Rechargeable LED Lantern

Suited for emergency situations or during periods of extreme climate conditions where lighting is essential. Supplied with cigarette lighter charger, mini USB cable and 3 x AAA rechargeable batteries.

- 360° rotating mode switch
- 6 x LED Lantern
- 0.5W LED Torch
- Size: 62(L) x 140(H) x 31(D)mm

ST-3121 ***was $34.95***

$19.95 SAVE $15

3.5" LCD Dash-Mount Colour Monitor

Mounts perfectly on your vehicle's dashboard and when not needed, folds down into a compact shell for dust-protected storage. With two video inputs, the rear vision view is automatically activated when your reversing gear is engaged.

- Crisp high resolution display
- Power: 12VDC 8W

QM-3771 ***was $89.00***

$79.00 SAVE $10

Digital Tyre Pressure Gauge

Keep track of tyre pressure and avoid pressure related problems. Measures pressure from 5 to 100PSI and includes an integrated torch for night time use.

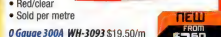
- includes 2 x AAA batteries
- Size: 156mm long

QP-2293 ***was $19.95***

$12.95 SAVE $7

Response 2-in-1 DC Power Cable

Features a red sheath that can be peeled off for a neutral opaque cable. Easy to convert your power cable to ground cable, no need to buy separate black and red power cable anymore.



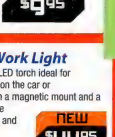
- Red/clear
- Sold per metre

0 Gauge 300A **WH-3093** $19.50/m
2 Gauge 200A **WH-3071** $14.50/m
4 Gauge 100A **WH-3065** $8.90/m
8 Gauge 60A **WH-3067** $3.60/m

NEW FROM $3.80/m

Digital Map Measure

Calculate distance between two points on a map or chart. The scale can be adjusted for any map.



- Backlight LCD
- Size: 23(L) x 35(H) x 5(W)mm

XC-0374

$9.95

Rechargeable Work Light

Features 51 LEDs and 3W LED torch ideal for camping, boating, working on the car or emergencies. Supplied with a magnetic mount and a hanging hook for hands free operation. Mains plug pack and 12V car charger included.

- Size: 460(L) x 60(Dia.)mm

ST-3260

NEW **$44.95**

7" Touch Screen LCD Colour Monitor with USB

Touch screen capabilities enables use with a laptop/PC, games console and other VGA operating devices. Use it to control a computer or any other USB compatible device. The monitor can be mounted either on the bracket or flush mounted with cradle. Software and adaptor cables included.

- Size: 178(W) x 122(H) x 30(D)mm

QM-3744

was $199.00

$179.00 SAVE $20

Digital Parking Assist System

Four sensor parking system with wireless connection from monitor to controller. Wireless range up to 30m make it suitable for larger vehicles such as trucks, buses, motor homes, caravans, etc.

- LCD
- 12VDC
- Display size: 72(L) x 53(W) x 17(D)mm

LR-8874

$99.00

12VDC Charger Cradle for iPhone® 3/4

Plugs directly into the car cigarette lighter and can also be used as a protector case. Perfect for both iPhone® generations.

iPhone® not included

- Power: 12VDC

HS-9012 ***was $24.95***

$19.95 SAVE $5

Weather Station/Clock/Photo Frame

Keep tab on the weather, the time and display photos of family and friends. A remote sensor sends weather data to the display unit which provides outdoor temperature, humidity, trend and forecast information and also displays indoor temperature. Photos can be loaded by PC, SD/MMC card or USB flash drive. Mains plugpack included.

BONUS SD CARD (XC-4998) VALUED AT $9.95

- Wall or desk mount
- Size: 200(W) x 150(H) x 30(D)mm

XC-0345

$129.00

Rechargeable CREE® LED Torch

Outputs 260 lumens of white light, great for every day around the house and more demanding uses such as hiking or caving adventures.

- Burn time: 5 hrs
- Built-in rechargeable Li-ion battery
- Mains charger included
- Size: 205(L) x 45(Dia.)mm

ST-3453 ***was $69.95***

$59.95 SAVE $10

Limited quantity.

GREAT SECURITY SAVINGS

4 Channel DVR Kit with 4 x 600TVL Cameras

Designed for locations which require superior video quality, the kit includes 4 x high grade 600TVL CMOS cameras, cables, power supply and a DVR with 500GB of storage plus additional features not found in economy DVR kits.

- H.264 video compression
- Recording resolution up to 704 x 576 (D1) at 25fps per channel
- Network interface for remote viewing via web browser, iPhone® or Smartphone*
- 600TV lines
- Size: 300(W) x 220(D) x 50(H)mm

QV-3032

*Free iPhone® or Smartphone app available for viewing live video.

Also available: *8 Channel DVR Kit with 4 Cameras* NEW QV-3034 $799.00

NEW $699.00

Video Door Peephole Viewer with Image Capture

Displays your visitor on a 3" LCD screen without pressing your face up to the door peephole. Install a MicroSD card (available separately) and the viewer will also capture an image of the peephole view every time the button is pressed. Image capture can also be triggered by adding a knock or PIR sensor module (available separately).

- Requires 2 x AA Batteries
- Peephole tube length: 33 to 45mm
- Viewer size: 158(H) x 87(W) x 32(D)mm

QC-3735

NEW $225.00

Sensor modules sold separately:

PIR Motion Sensor	QC-3736	$84.95
Vibration Knocking Sensor	QC-3737	$44.95

3.5" LCD Camera Kit

The 3.5" TFT LCD gives real-time video monitoring and the microphone in the camera provides audio either through the speaker in the display unit or via headphone outlet. 20m power/video cable and mains plugpack included.

- IR illuminator
- CMOS sensor
- Size: 130(W) x 80(H) x 22(D)mm

QC-8007 ***was $149.00***

Spare camera also available: QC-8009 $69.00

$99.00 SAVE $50

Outdoor 600TVL CMOS Camera

DUE EARLY OCTOBER

Housed in a waterproof black anodised case, the camera features a high quality colour CMOS sensor, sun-shade, and IR LEDs. Supplied with 12VDC power supply and 18m combined video and power lead. Ideal for surveillance applications and suits all our DVRs.

- 600TV Lines
- Size: 135(L) x 85(H) x 68(W)mm

QC-8632

NEW $99.00

2-Zone Alarm Kit

Simple two zone, two wire alarm for small to medium size premises. Included is one passive infrared sensor for large areas and a reed switch for one entry point such as a door or window. Additional sensors (available separately **LA-5481** ***$24.95***) can be added if required.

BONUS PIR Sensor (LA-5481) valued at $24.95

- Includes: 2-Zone control unit, PIR sensor, Reed switch & 25m cable

LA-5480

$89.00

PIR Detectors

For home or office security applications. Both units are compact, attractive and easy to install. Features include excellent false alarm suppression. The quad element unit offers higher levels of detection.

- 9 - 14VDC
- Size: 104(H) x 66(W) x 47(D)mm

FROM $29.95

Dual Element	LA-5044	$29.95
Quad Element	LA-5046	$39.95

Network Connect Vandal Proof Mini Dome Camera 2MP

Access your CCTV system via the Internet or your local intranet. This dome camera connects straight to your existing network for complete control. Access the camera through a web interface by hitting the IP address of the device and logging in. The web interface allows you to adjust visual settings, record, take snapshots and setup scheduled events.

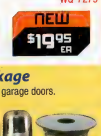
- Video compression: H.264/MJPEG
- CMOS camera sensor
- 12VDC, PoE
- Size: 110(Dia.) x 54(H)mm

QC-8626

$299.00

CCTV Video and Power Cables

Make running cables between your camera and your DVR a breeze using this integrated video and power cable. Each cable is terminated with video and DC power connectors.



- 18m length

BNC Plug - BNC Plug CCTV Cable with Power **WQ-7279** $19.95

WQ-7279

BNC Plug - RCA Plug CCTV Cable with Power **WQ-7271** $19.95

NEW $19.95 EA

Doorway Beam Package

Perfect for use across gateways or garage doors. Designed to be used in genuine commercial environments such as warehouses and parking lots.

- 30m range

Includes:

- Commercial Grade Beam Detector (LA-5196 $89.95)
- 12VDC 400mA Power Supply PSU (MP-3147 $17.95)
- Buzzer (AB-3462 $3.95)
- 30m Cable (WB-1703 $12.95)

Total package value: $124.80

$95.00 SAVE $29.80

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

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Shepparton Ph (03) 5822 4037
Springvale Ph (03) 9547 1022
Sunshine Ph (03) 9310 8066
Thomastown Ph (03) 9465 3333
Werribee Ph (03) 9741 8951

• WESTERN AUSTRALIA

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Maddington Ph (08) 9493 4300
NEW Mandurah Ph (08) 9586 3927
Midland Ph (08) 9250 6200
Northbridge Ph (08) 9328 8252
Rockingham Ph (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details.

Prices valid from 24th September to 23rd October 2012.

HEAD OFFICE
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100 Fax: (02) 8832 3169

ONLINE ORDERS
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Jaycar electronics
Better. More Technical.

GREAT GIFTS & GADGETS SAVINGS

Convert Slides, Film & Photos to Digital

Easy DIY way of digitally archiving, sharing and saving cherished photos.

CRAZY LOWEST PRICE!

Laptop not included

- 5MP, 1800dpi resolution
- Windows compatible
- Size: 85(W) x 165(H) x 90(D)mm

XC-4881 ***Originally $74.00***

$45.00

USB Slide/Film Scanner

Scan directly to your PC using the provided software.

USB Photo Scanner

Features an 8MP sensor and white LED lighting and it will produce clear high resolution scans quickly. Enables you to do basic photo editing such as crop, straighten, retouch and colour adjust. See website for full specs and system requirements.

CRAZY LOWEST PRICE!

- Four photo sizes: 3.5 x 3.5", 3.5 x 4.5", 3.5 x 5.0", 4.0 x 6.0"
- PC & MAC® compatible
- USB 2.0

XC-4910 ***Originally $129.00***

$69.00

USB Combo Image Scanner with LCD

Connect this to your PC and take high resolution scans of all your photos, slides and negatives to preserve in JPEG or TIF format.

CRAZY LOWEST PRICE!

- 5MP, 1800dpi, 2.4" LCD
- Size: 210(L) x 230(W) x 150(H)mm

XC-4893 ***Originally $199.00***

$129.00

LED Remote Controlled Open/Closed Sign

High visibility shop sign with LED open/closed display has high intensity LEDs can be seen from a considerable distance. The display is remote controlled and runs from a 9V mains adaptor.

- Clock function
- Size: 362(W) x 242(H) x 25(D)mm

XC-0200 ***was $169.00***

$99.00 SAVE $10

Portable Camping Shower

Battery powered so you can use it almost anywhere. Drop the submersible pump into a clean water supply, hang the shower head in a convenient location, and you're ready to wash!

- Requires 4 x D batteries
- Hose length: 2.5m

YS-2802

NEW **$49.95**

Headrest Mounting Bracket for iPad® 1

Just mount the bracket to the metal bars on the car seat headrest and place the iPad® into the cradle. Couldn't be easier.

- Size: 244(L) x 188(W) x 15(D)mm

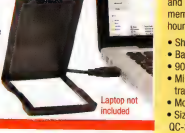
HS-9010 ***was $24.95***

NOTE: iPad® not included

$19.95 SAVE $5

USB Business Card Scanner

Save your business card contacts directly to an Outlook/Outlook Express address book. Using optical character recognition it extracts text from the business card and categorise it into 13 different fields.



Laptop not included

- Scans single or double sided business cards
- Sensor: 1.3 Mega Pixels
- Operating System: Windows XP/Vista/7
- Size: 120(L) x 70(W) x 20(D)mm

XC-4908 ***was $79.95***

$39.95 SAVE $40

Portable Ceiling Fan and Light

Simply hang it where airflow is needed. Features soft foam blades for safety, two fan speeds, and in-built LED downlight.

- Requires 4 x D batteries
- Maximum Run Time: 48h
- Size: 220(Dia.) x 145(H)mm

YS-2804

NEW **$34.95**

High Speed RC Truggy

Travels up to 18km/h and has a 4WD shaft drive with extra large volume shocks for optimal handling. The high-grip tyres are ideal for sharp corner turns and scaling up hills. Rechargeable battery and charger included.

Drive 2 at once without conflict

- 4hr charge for 12 min driving time
- Suitable for ages 14+
- Size: 335(L) x 270(W) x 115(H)mm

GT-3687 ***was $79.95***

$69.95 SAVE $10

35mm Photo Frame Keyring

Holds up to 100 photos which can be downloaded from a MAC® or PC. Unit features an LED torch and comes with a stand and mini USB lead.

CRAZY LOWEST PRICE!

- Size: 66(L) x 42(W) x 13(D)mm

XC-0211 ***Originally $24.95***

$19.95

Spy Camera

This tiny camera is designed to mount on large model helicopters, planes and cars. 4GB internal memory gives about 4 hours of video, 30 grams.

CRAZY LOWEST PRICE!

- Shockproof construction
- Ball swivel lens
- 90° viewing, 60° rotation
- Mini USB socket for video transfer and charging
- Mounting bracket included
- Size: 80(L) x 19(Dia.)mm

QC-3820 ***Originally $99.00***

$49.95

4 Channel IR Gyro Helicopter

Fly to Pandora and back! Dip, turn, spin or hover just like you see in the movies. Fly 3 at once without conflict.

- Gyroscope and 4 motors for stable flight
- Charge via remote control
- 50 min charge for up to 7 min flight time
- Remote requires 6 x AA batteries
- Suitable for ages 14+
- Size: 230mm long

GT-3386 ***was $49.95***

$39.95 SAVE $10

Mini RC Helicopter with iPhone®/Smartphone Control

Control from your iPhone®/iTouch®/iPad® or Android™ Smartphone using free app available on iTunes®. Fly 3 at once without conflict.

iPhone® not included

- 3 Channel
- Gyroscope for stable flight
- 25 min charge for 5 min flight time
- Infrared transmitter
- Includes USB charger
- Suitable for ages 14+
- Size: 135mm long

GT-3460 ***was $79.95***

$49.95 SAVE $30

3 Channel Single Blade RC Helicopter

The advanced single blade design offers better performance, speed and manoeuvrability than its double bladed counterparts. This 3 channel helicopter allows a wider range of movement and has a built-in gyroscope for stability.

- 2hr charge for 8min flight time
- Remote requires 6 x AA batteries
- Frequency: 27MHz
- Suitable for ages 14+
- Size: 390mm long

GT-3490 ***was $89.95***

$69.95 SAVE $20

8 Port 10/100 Network Switch

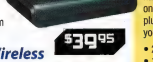
Network your computers or share your ADSL connection, and avoid hassles with file sharing and internet access. Operates up to 10/100 Mbps.

- Size: 159(W) x 103(D) x 27(H)mm

YN-8084 **$24.95**

Single Port ADSL2+ Modem

Get online quickly with this affordable, feature packed unit. Setup is simple with the web management tool which gives you access to connection types, security options, and virtual server settings for port forwarding so can you use all your favourite apps and games without issue.



- Includes 1 x splitter/filter
- Compatible with all major ISPs
- Size: 150(L) x 95(W) x 25(H)mm

YN-8316 **$39.95**

802.11n Wireless Broadband Router

Offering the latest in high speed technology, this excellent router can handle data transfer rates up to 300Mbps and achieve three times the transmission range of 802.11g systems. Integrates a router, wireless access point, four-port switch, and firewall all in one compact package. See website for full specifications.

- 802.11n, 802.11g, 802.11b protocols
- 300Mbps receiving and 150Mbps transmission rates
- SSID stealth mode and MAC address filtering

YN-8300 **$69.95**

NOTE: Actual product may differ from picture shown

IPTV Internet Digital TV Tuner

With this unit you can watch your favourite TV shows from anywhere in the world. Time shifting and scheduled recording are also supported so you can pause and rewind live TV. See website for more details.

- Windows compatible

XC-4861 **$99.00**

Originally $169.00

CRAZY PRICE!

NOTE: Time shifting requires Windows Vista®

Hurry! Limited Stock

USB 2.0 DVD Maker II

Turn your aging collection of VHS video tapes into new video productions. Works on PC or MAC® and the included software allows editing/publishing for web applications etc.

- Composite video input via RCA connector or S-Video mini-DIN
- Windows & MAC® compatible
- Size: 35(W) x 95(D) x 15(H)mm

XC-4867 **$69.95**

Docking Station for iPad®/iPhone®/iPod®

Listen to tunes from an iPad®,iPhone® or iPod® with this docking station. Connects up to powered speakers using the 3.5mm audio input to the docking station. Charge and synchronize devices to a PC or MAC® simultaneously. Includes a Micro B USB lead and a 3.5mm to 3.5mm audio cable.

iPhone® not included

- Supports iPad®, iPad® 2, iPhone® 3GS/4 and iPod® Touch
- Size: 100(L) x 80(W) x 25(H)mm

WC-7718 NEW **$49.95**

2.4GHz Wireless Keyboard with Trackball

Designed for use with PC-based home theatre, this keyboard has a trackball and a set of mouse buttons conveniently located on the underside (also a second set on top). Simply plug in the USB wireless receiver to your PC and you're good to go.

CRAZY PRICE!

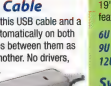
- 2.4GHz with 8 channels
- 10 metre range
- Windows compatible
- 12 Internet/multimedia hot keys
- Integrated optical trackball & scroll wheel
- Requires 4 x AA batteries

XC-4941 *Originally $79.00* **$49.00**

Hurry! Limited Stock.

All-In-One Card Reader

Supports SD, MMC, MS and CF formats including Micro-drive. See website for full list.



- USB 2.0
- Size: 60(L) x 40(W) x 13(H)mm

XC-4849 *was $24.95* **$19.95** SAVE $5

USB File Transfer Cable

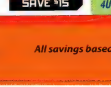
Simply connect two PCs with this USB cable and a file-sharing window opens automatically on both computers. Drag and drop files between them as easily as from one folder to another. No drivers, software or plug-ins to install.

- Supports Windows
- Transfer rate of 16MB/second
- 1.8m long

XC-4942 *was $29.95* **$24.95** SAVE $5

RCA to USB Digital Converter

Suitable for converting any line-level audio device to USB for stereo PC recording. Simply install the included Magix Audio Cleaning Lab SE & Audacity software to import your music & optimise sound recording quality.



- 16-bit 44.1kHz digital audio output
- Gold plated terminals
- Suitable for PC & MAC®
- Cable Length: 1.2m

GE-4050 *was $49.95* **$34.95** SAVE $15

4 Port USB 2.0 Networking Server

Plug this device into your router with a Cat 5 cable (not included) then plug in a USB powered product and computers will be able to see and use your USB gadgets from any computer. Ideal for printers, scanners or for access to your external hard drives.

Back

Front

- Supports up to 4 devices at the same time

YN-8406 *was $69.95* **$59.95** SAVE $10

Screen Cleaner Kit for Small Devices

Clean small screens including iPhone®, mobile phones and cameras. Removes fingerprints, dust and stains without scratching the screen. Supplied with a washable microfibre finger cloth and a 12ml cleaning solution bottle.

iPhone® not included

- Size: 90(H) x 45(W) x 22(D)mm

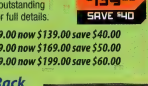
AR-1415

Also available: LCD Screen Cleaning Kit for Large TVs NEW AR-1417 $9.95

NEW **$6.95**

19" Rack Mount Enclosures

Ideal for studios, PA, sound reinforcement, IT, or phone systems installations. Coupled with our wide range of accessories and options, this 19" rack cabinet offers outstanding features. See website for full details.



HB-5170 FROM **$139.00** SAVE $40

6U HB-5170 *was $179.00 now $139.00 save $40.00*

9U HB-5172 *was $219.00 now $169.00 save $50.00*

12U HB-5174 *was $259.00 now $199.00 save $60.00*

Swing Frame Rack Mount Enclosures

Swing frame enclosures allow you to access the rear of your rack system for maintenance or easier installation. Tempered glass doors and locking panels all round.

HB-5182 FROM **$199.00** SAVE $50

6U HB-5180 *was $249.00 now $199.00 save $50.00*

12U HB-5182 *was $329.00 now $299.00 save $30.00*

Open Wall Mount Rack Enclosures

Ideal for mounting in other enclosures, such as road cases, but can also be mounted stand-alone. One side is hinged so that patch panels can be easily accessed at the rear for reconfiguring patch sets.

HB-5190 FROM **$39.95**

2U HB-5190 $39.95

4U HB-5192 $49.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/10/12.

GREAT SPRING SAVINGS

Jaycar Electronics — Better, More Technical

BUY NOW & SAVE $$$. SAVE UP TO 70% OFF.

Please ring your local store to check availability. At these prices we won't be able to ship from store to store. ITEMS WILL SELL FAST AND STOCK IS LIMITED. ACT NOW TO AVOID DISSAPOINTMENT. Sorry NO RAINCHECKS.

Savings OFF Original RRP

IT Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
XC-4876	12V ATX Computer Power Supply for Cars	$99.00	$79.00	$20.00
AR-3271	Antenna 2.4GHz Ceiling-Mount	$49.95	$14.95	$35.00
XC-4142	Converter Express Card to ESATA+Power	$49.00	$19.00	$30.00
XC-4140	Converter Express Card to USB2	$39.95	$19.95	$20.00
XC-4141	Converter Express Card to USB3	$59.95	$39.95	$20.00
AA-2078	Headphones/Microphones for Computer	$19.95	$14.95	$5.00
YN-8420	IP Power Controller 4 Way	$199.00	$169.00	$30.00
XC-5151	Keyboard USB Pink with Optical Mouse Kit	$35.00	$20.00	$15.00
WC-7794	Lead 2m USB A plug to A plug	$14.95	$9.95	$5.00
WC-7790	Lead 2m USB A plug to B plug	$14.95	$9.95	$5.00
YN-8209	Lead Cat5E Patch Retractable 1.5m	$7.95	$4.95	$3.00
PS-0032	Memcard 4in1 Socket MMC, SD, MS, SM	$18.95	$9.95	$9.00
XM-5246	Mouse USB Mini Rechargeable	$29.95	$24.95	$5.00
XM-5132	Mouse USB Optical 5Button	$24.95	$19.95	$5.00
XM-5242	Mouse USB Optical Mini 3Button	$9.95	$7.95	$2.00
XC-4839	Remote Control for Home Theatre 2.4GHz & IR	$89.00	$59.00	$40.00
XC-5178	Speaker Mini Keychain Rechargeable	$19.95	$9.95	$10.00
XC-5193	Speaker Notebook NXT Clip-On	$34.95	$19.95	$15.00
XC-4886	TV Tuner Digital USB	$69.00	$49.00	$20.00
XC-4944	USB Device Share Hub (1 device, 2 computers)	$24.95	$14.95	$10.00
QC-3237	Web Camera 720P with Microphone	$39.95	$29.95	$10.00

USB Roll-up Keyboard White Illuminated

Original RRP $49.95
Special Price $24.95
Save $25.00

XC-5147

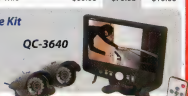
Security Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
QC-3251	Baby Monitor System 2.4GHz with LCD & Night Vision	$169.00	$129.00	$40.00
DC-1024	Baby Monitor Transmitter suits UHF CB Radios	$69.00	$29.00	$40.00
QC-3467	Camera CCD - B&W Bullet IP57 380TVL	$99.00	$49.00	$50.00
QC-3301	Camera CCD Day/Night HRes 470TVL Colour	$299.00	$129.00	$170.00
QC-3296	Camera CCD ExView 380TVL Colour	$249.00	$119.00	$130.00
QC-3299	Camera CCD ExView HRes 470TVL Colour	$349.00	$149.00	$200.00
QC-3310	Camera CCD Pro Style 380TVL B&W	$109.00	$69.00	$40.00
QC-8015	DVR and Bullet Camera Package Mini	$269.00	$199.00	$70.00
QC-3315	Lens Camera Standard C Mount 4mm	$24.95	$9.95	$15.00
QC-3317	Lens Camera Standard C Mount 8mm	$24.95	$19.95	$5.00
LR-8861	Parking Sensor with Beeper	$49.95	$19.95	$30.00
QC-8013	PIR Driven Security Camera	$69.95	$59.95	$10.00
LA-5123	RFID Keypad Access Controller	$169.00	$79.00	$90.00
QC-8004	Video Pen Camera 4GB	$79.95	$59.95	$20.00
QC-3256	Video Recorder HD Mini Waterproof	$149.00	$99.00	$50.00
QC-3263	Video/Power Processor CCTV 2-Wire	$89.95	$79.95	$10.00

7" LCD Monitor Surveillance Kit with 2 x CMOS Cameras

Original RRP $199.00
Special Price $149.00
Save $50.00

QC-3640



Lighting Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
SL-2745	Globe Halogen MR16 20W	$8.95	$2.95	$6.00
ZD-0306	Globe LED Bayonnet 6V	$26.95	$9.95	$17.00
SL-3213	Globe Torch 3V Pk2	$2.95	$2.00	$0.95
SL-2931	Green Laser Star Projector	$119.00	$79.00	$40.00
ST-3404	LED AA Mini Maglite® Upgrade with IQ Switch	$34.95	$29.95	$5.00
ST-3047	LED Keyring Light Blue	$9.95	$6.95	$3.00
ST-3183	LED Light Sensor Strip Kit	$39.95	$29.95	$10.00
SL-2723	Light Globe Halogen 35W 24V	$4.95	$2.95	$2.00
SL-2743	Light Globe Halogen 38D Lens 50W 12V	$7.95	$4.95	$3.00
SL-2732	Light Globe Halogen MR16 50W 12V	$7.45	$2.95	$4.50
ZD-0476	Light LED Flexible Adhesive Strip 12V 3xRGB	$3.95	$2.95	$1.00
ZD-0473	Light LED Flexible Adhesive Strip 12V 3xWhite	$2.95	$1.95	$1.00
ST-3189	Light LED Wall Mount	$19.95	$9.95	$10.00
ST-3383	Torch LED AAA Battery-shaped	$4.50	$2.50	$2.00

94 LED DMX Control Spotlight PAR 46

Original RRP $139.00
Special Price $119.00
Save $20.00

SL-3422

Power Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
SB-2574	Battery for iPod 4G/Photo Li-ion 3.7V 580mAh	$23.95	$14.95	$9.00
SB-2579	Battery for iPod Nano 3.7V 1G 300mAh	$22.95	$9.95	$13.00
SB-1612	Battery Back-up Ni-MH 140mAh 3.6V	$13.95	$9.95	$4.00
SB-1609	Battery Back-up Ni-MH 70mAh 3.6V	$9.95	$7.95	$2.00
MB-3622	Battery Charger 5Stage 15A 240VAC	$149.00	$99.00	$50.00
MB-3583	Battery Charger Pack Ni-Cd & Ni-MH	$89.95	$79.95	$10.00
SB-2412	Battery Lithium AA 3.6V	$29.95	$19.95	$10.00
SB-2302	Battery Ni-MH 6V 1600mAh Hump-Pack	$29.95	$24.95	$5.00
SB-1755	Battery Ni-MH AA 1450mAh Pk2	$17.95	$9.95	$8.00
SB-1613	Battery Ni-MH Sub C 2700mAh Tag	$8.95	$6.95	$2.00
MP-3204	Converter Module DC/DC 9-18V to 5V 600mA	$32.95	$19.95	$13.00
MS-6116	Mains Power Meter 3-Outlets Wireless	$99.95	$59.95	$40.00
MP-3179	Power Supply Switchmode 100W 24V Open Frame	$69.95	$49.95	$20.00
MP-3128	Solar Charge Controller 12V 6A	$49.95	$34.95	$15.00

Multifunction 200W Inverter

Original RRP $69.95
Special Price $39.95
Save $30.00

MI-5103

Tools, Test & Measurement Products

Cat No.	Product Description	Original RRP	Special Price	SAVE
QM-1567	DMM Clamp Fixed Jaw CATIV	$179.00	$89.00	$90.00
QM-1546	DMM Rechargeable Solar	$119.00	$69.00	$50.00
WT-5340	Lead DMM with Blade Fuse Fitting	$11.95	$9.95	$2.00
QM-3533	Magnifying Lens FRESNEL	$5.95	$3.95	$2.00
TD-2108	Screwdriver 10-in-1	$14.95	$9.95	$5.00
QT-2216	Semiconductor Component Analyser	$99.00	$49.00	$50.00
AA-0406	Tester HDMI Cable	$149.00	$59.00	$90.00
QP-2214	Tester Polarity Check 3-15V Input	$11.95	$5.00	$6.95

Cat No.	Product Description	Original RRP	Special Price	SAVE
QT-7200	Thermostat 5-35°C 5A/250V	$47.95	$39.95	$8.00
TS-1365	Tip (Weller) 1.6mm Flat 430°C	$19.95	$14.95	$5.00
TH-1930	Tool Assembly for Solar Power Connectors	$9.95	$5.95	$4.00
TH-1941	Tool IDC Crimp	$14.95	$8.95	$6.00

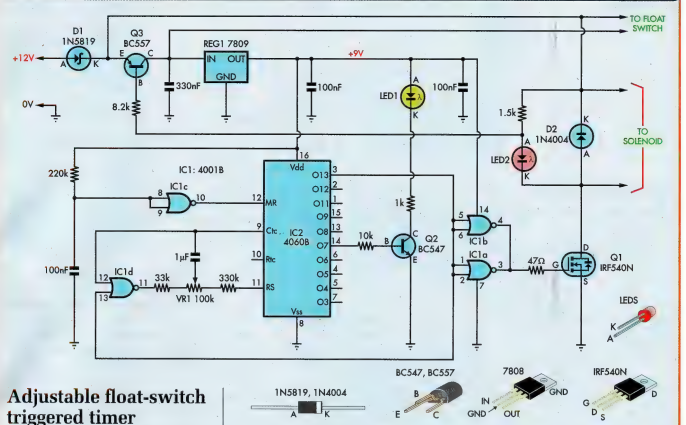
USB Sound Level Meter

Original RRP $149.00
Special Price $109.00
Save $40.00

QM-1599

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Adjustable float-switch triggered timer

This circuit is triggered by a float switch when water rises past a certain level and it then turns on a solenoid for a predefined period to open a valve, draining the water. It could also turn on a pump or other 12V DC load up to about 10A. The on-period for the load is variable over a range of 10-35 minutes.

IC2 is a 4060B binary counter with in-built oscillator. It's driven by NOR gate IC1d which operates as a gated oscillator. When output O13 of IC2 is low, the oscillator runs and its timing is set by the combination of fixed 33kΩ and 330kΩ resistors, potentiometer VR1 and the 1µF capacitor from the pin 9 output of IC2.

Pin 9 of IC2 outputs a buffered digital signal which follows input pin 11. This is fed back into one of IC1d's inputs. Since IC1d is an inverter, this makes the circuit astable and thus it oscillates. Varying the setting of VR1 changes the RC time constant of the delay circuit from IC1d's output to pin 11 of IC2, varying the frequency.

IC2's O7 output drives NPN transistor Q2 which in turn drives LED1 via a 1kΩ current-limiting resistor. LED1 flashes at 1/256th ($1/2^8$) of the frequency at IC2's pin 11 input.

While IC2's O13 output is low, the gate of Mosfet Q1 is driven high by IC1a & IC1b which are configured as inverters and wired in parallel. This turns on the solenoid and also red LED2. After 8192 (2^{13}) oscillator pulses, output O13 of IC2 goes high, turning off the Mosfet and the solenoid. Diode D2 absorbs any back-EMF from its inductive windings.

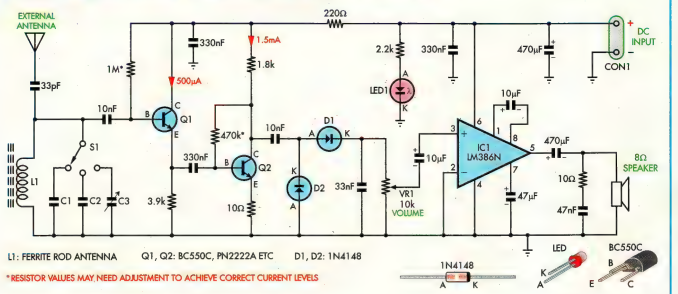
The circuit is activated by the float-switch wired across the emitter and collector of PNP transistor Q3. When the switch contacts close, 12V power flows to 9V regulator REG1 via the switch contacts and reverse polarity protection diode D1.

The 9V supply powers both ICs and when it is first applied, inverter IC1c resets IC2, initialising the counter to zero. Once the 100nF capacitor at the inputs of IC1c charges, its output goes low and the timer runs, turning on the solenoid for the set period.

As long as the solenoid is on, the base of PNP transistor Q3 is pulled low via an 8.2kΩ resistor, allowing current to pass to the 9V regulator even when the float switch contacts open. Q3 turns off when the solenoid does and so the circuit powers down, ready to be activated again by the float switch.

To set the timer, you activate the circuit by closing the float switch contacts and then measure the period that green LED1 is on when it flashes. This will be 1/64th the load on-time. Adjust VR1 for the appropriate flash period. For example, if you want the load to run for 15 minutes, adjust VR1 until LED1 flashes on for 15 x 60 ÷ 64 = 14 seconds each time.

Len Cox,
Forest Hill, Vic. ($50)



Simple AM radio uses discrete parts

Were you interested in the simple AM radio featured in the January 2012 issue? That radio circuit employed an MK484 3-pin IC which includes RF amplification, detection and automatic gain control (AGC).

By contrast, the circuit described here demonstrates that you don't necessarily need the MK484 to build a simple AM radio; you can do it with discrete components. Nor do you need specialised RF transistors as the gain-bandwidth product (f_T) of small signal silicon transistors is generally more than adequate.

Just as in the January 2012 design, this circuit has a ferrite rod antenna connected in a parallel resonant network with a variable capacitor. Its output is fed to an RF amplifier comprising two audio transistors and these in turn feed a diode pump consisting of diodes D1 & D2 and two capacitors. The detected audio signal appears across 10kΩ volume control potentiometer VR1 and is then fed to an LM386 power amplifier chip; again very similar to the January 2012 design.

The resulting circuit doesn't have AGC but will have a similar performance to the earlier design and will be adequate if you don't need to tune right across the AM band.

The circuit can be run from any DC supply over the range from about 4.5-12V. Note that the base bias resistors for Q1 & Q2 may need to be varied in order to get the collector currents indicated on the circuit.

Petre Petrov,
Sofia, Bulgaria. ($40)

Lap counter for track or pool

This Lap Counter features two Jumbo (57mm high) 7-segment displays and records up to 99 laps. It runs on a battery for safety in wet areas. It is controlled by a parent or coach pressing a "count" button (S1) but may also be operated by the competitor using an optional "remote" button. Normally, this would be a very large pushbutton or air-operated button but could be a pressure pad, touch pad or a light beam relay.

A PICAXE 20M2 microcontroller (Ic1) performs the count and displays the result. Before switching on you must fit a "mode" jumper. Select "lap" mode for running or cycling etc. This adds one each time the "count" button is pressed.

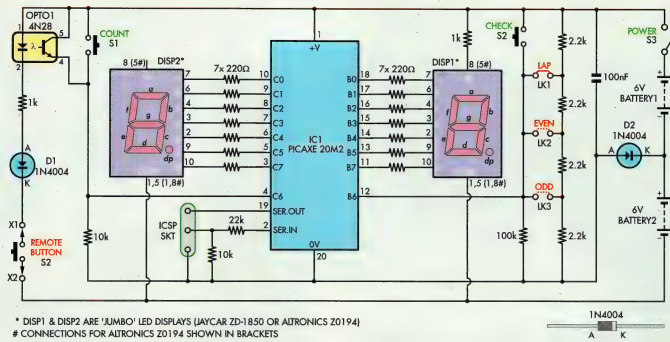
The "even" and "odd" modes are for swimming, adding two each time the "count" button is pressed. Use the "even" mode when the Lap Counter is placed at the start end of the pool, or select the "odd" mode at the other end of the pool (see the program notes).

Turning on the Lap Counter with power switch S3 will clear the counter and display zero for five seconds. S3 is also used to reset the Lap Counter.

For extended battery life, the LED display is only operated for five seconds each time the "count" button is pressed. During this period, the "count" button is deactivated to prevent multiple counts being recorded. You may also press "check" button S2 to view the current lap count but not near the end of a lap or the next count may be missed.

The display segments are individually driven by the PICAXE 20M2 using 220Ω current limiting resistors. To obtain the same brightness with a multiplexed display would require additional driver ICs. The ability to drive two displays was tested by continually displaying "88" for a 2-hour period and the microprocessor remained cool and operated normally.

The Jumbo 7-segment displays each contain four series-connected LEDs in each segment, resulting in a combined forward voltage drop of 8V and with the drop across the 220Ω resistor included, this requires a 12V supply. Two 6V battery packs are employed, allowing the microprocessor to run on one 6V battery



* DISP1 & DISP2 ARE 'JUMBO' LED DISPLAYS (JAYCAR ZD-1850 OR ALTRONICS Z0194)
# CONNECTIONS FOR ALTRONICS Z0194 SHOWN IN BRACKETS

with a series diode (D2) to obtain a 5.4V supply.

The prototype was powered from eight AA alkaline cells held in a pair of 4-way battery holders.

The forward voltage drop across each segment is similar to an 8V zener diode and limits the voltage on the PICAXE 20M2 pins to a safe level. The display decimal point is slightly different, having only two LEDs and is driven with a 1kΩ current limit resistor.

Only the "units" decimal point is used and this functions as a power on indicator. This gives a reminder to turn the Lap Counter off (when not in use) because the main display is often blank.

The PICAXE 20M2 has two power supply pins, two serial programming pins, eight PortB pins and eight PortC pins. Both ports are bidirectional, allowing the pins to be configured as either inputs or outputs. In practice, 14 pins are used as outputs to drive the two 7-segment LED displays and two pins are used as inputs.

The first input is the "count" input (pin 4 of IC1) which is operated by the main "count" button (S1) and by the optocoupler (OPTO1) and the "remote" button (S2). This optocoupler keeps electrical noise on the external wiring away from the microprocessor.

The second input is the "mode" input (pin 12). This operates as an analog input and has multiple functions. Pressing the check button (S2) will take this pin high, showing the current lap count.

Three jumpers and a number of 2.2kΩ resistors vary the pin 12 voltage to select the count mode (lap = ¾ rail voltage, even = ½ rail voltage and odd = ¼ rail voltage). The program detects the selected voltage level and acts accordingly.

You will need to use the serial programming socket to load **lapcounter_20m2.bas** (available on the SILICON CHIP website) into the PICAXE 20M2 microprocessor.

Ian Robertson,
Engadine, NSW. ($60)

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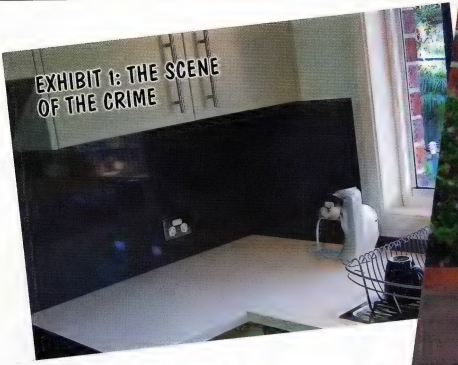


Simple circuit uses a PIR sensor to detect movement. Use it as a cat deterrent, door minder or burglar alarm . . .

The Nick-Off Bad Cat Deterrent

Do you have a miscreant "puddy-tat" that likes to jump on kitchen benches (or worse)? It can be a real problem, especially at night when no-one is looking. The Nick-Off Cat Deterrent (aka the Ted-Off) is the perfect solution. It uses an infrared sensor to detect said cat and triggers an answering machine to play back simulated, demented barking. It also lights two white LEDs which form the eyes of an angry dog.

ALLOW US TO introduce Ted. Ted is a 13-year-old black-and-white de-sexed male moggie and is the much-loved pet of a family friend.

According to his owner, Ted's had 13 years of practice getting humans to do exactly what he wants them to do. Want to be fed? Make a first-rate nuisance of yourself until a human complies with the goodies. Want to go outside? Dig your claws into the screen door, or claw the carpet or start ripping the newspaper under the food bowl to shreds. Any one of those actions is absolutely guaranteed to attract attention and gain the necessary compliance from Ted's owner.

Apart from that and some minor indiscretions such as the occasional fight (and a trip to the vet for repairs), Ted has been relatively trouble-free. Until recently, that is, when Ted developed a rather revolting habit.

You see, Ted has the run of a downstairs living area at night, comprising a kitchen/dining room, a rumpus room and the laundry (with his litter tray). But just recently, after 13 years of being a good pussy cat, Ted suddenly decided that he was going to jump

Article: Greg Swain
Circuit : Nicholas Vinen

up on the kitchen bench at night and scent-mark the glass splashback in one particular corner of the kitchen.

The result each morning was a smelly liquid pool that had to be thoroughly cleaned up and the splashback and benchtop washed down with disinfectant – not a pleasant job. And he didn't do it just a few times. Having started the practice, it quickly became a habit, much to his owner's disgust and annoyance.

Ted's human has a theory as to why he suddenly started doing this. Just before the first incident, he had been shoved into a pet box and unceremoniously carted off to the vet for his annual flu injection. And while he was waiting for said injection, Ted had been forced to share the waiting room with a rather boisterous and over-friendly Labrador.

Ted was not at all impressed with this and the subsequent flu injection only added to his trauma and bad temper. Having had his jab, he was taken home and released from the confines of his pet box, whereupon he immediately made plain his considerable displeasure by attacking his scratching post.

And then that night, the indiscretions started. Perhaps it was Ted's revenge for the vet trip or perhaps it was to re-establish territory and to let everyone know who really was the boss. But whatever the explanation, the result was . . . uggghhhh!!

A solution

Shortly after he started his shenanigans, Ted's owner asked me if I knew of an electronic device, perhaps an alarm, that would keep him off the bench. A quick search on Google soon revealed the "Sscat", a battery-powered device that combines a motion detector (presumably a PIR sensor) with a can of harmless, odourless spray. The device detects the cat's movement out to about 1m and releases a brisk spray to warn the cat off.

That got me thinking. I had a spare PIR (passive infrared) sensor, as used in burglar alarm systems, plus an old analog telephone answering machine tucked away in a drawer. Could I combine them somehow so that the PIR sensor triggered the answering machine when movement was detected?

As with most telephone answering machines, this one had a message

It Has Other Uses

This circuit is basically a simple movement detector/alarm circuit with a 30s exit delay and two outputs: one to simulate a button press and the other to drive two series LEDs or a relay (or some other load) for an adjustable period ranging up to 60s. **As such, it could also be used as a shop minder or as a simple, low-cost burglar alarm for a garage. Or it could be used just to trigger a message machine or activate some other device when movement is detected (eg, close to a display counter).**

You don't have to use a PIR sensor to trigger the device either. The Nick-Off can be used with virtually any sensor that features NC or NO contacts, eg, a reed switch or pressure mat.

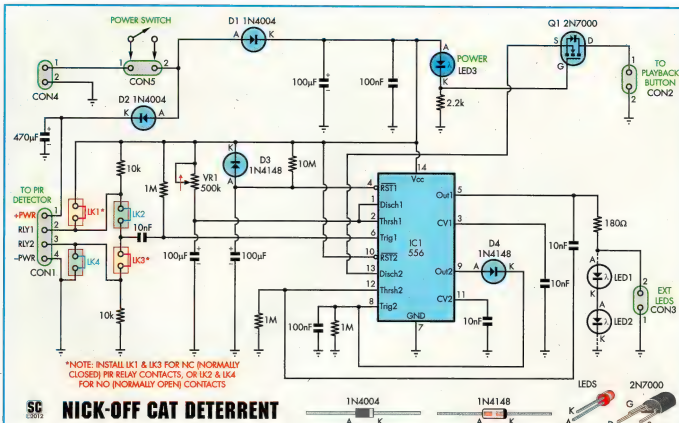


Fig.1: the circuit is based on IC1, a 556 dual-timer IC. This is triggered by the PIR and generates a short pulse to trigger the answering machine via Mosfet Q1 and a longer pulse (up to 60s) to drive two high-brightness LEDs (LEDs1 & 2).

pushbutton that you momentarily press to play back the recorded message. In theory, it would be just a matter of processing the output from the PIR sensor to simulate this button press.

A simple transistor circuit was quickly lashed up on stripboard and this proved the basic concept. This circuit detected when the NC (normally-closed) relay contacts in the PIR sensor opened (ie, when movement was detected) and produced a brief low-going pulse at its output. This output was wired across the message button in the answering machine (to simulate the button press) and it worked like a charm.

By then recording a suitably scary barking sound on the answering machine, it just might do the trick. In practice, this was more of a demented ***WOOF WOOF WOOF WOOF WOOF . . . Get-Ooorrrf-There-Ted . . . WOOF WOOF WOOF Grrrr WOOF WOOF*** sequence, which I imagined would have the desired effect.

Introducing the Ted-Off

Having established that the circuit worked, I decided to build the prototype into a spare biscuit tin, with the PIR sensor attached to one side. At the same time, a scary bulldog graphic was also added to the lid, along with a couple of white LEDs for his eyes. These LEDs required an extra transistor and lit up for around 30s each time the device was activated.

And so was born the "Ted-Off", named in honour of the miscreant himself. It was duly installed in my friend's kitchen for its maiden run.

Did it work?

Ted was nailed by the Ted-Off on the very first night. At 3.15 in the morning. Just when you would least expect it.

As Ted's owner put it, the demented barking sound from the answering machine, at full volume, in the middle of the night was enough to awaken the dead. Her first thought was "what the hell's that?" and then, having realised what it was, she rushed down the stairs and opened the door into the kitchen . . . just in time to spy Ted's hindquarters disappearing under one of the chairs around the dining table.

Eureka!! – it had worked and there wasn't a scent mark anywhere.

Not only that but it has since proved to be a very effective deterrent. After the shock of that first encounter, Ted behaved himself for quite some time before getting sprung again about 10 days later. And that was it – despite several months having now passed, the Ted-Off has since remained mute and Ted has kept out of the kitchen at night.

According to his owner, just having the device sitting on the kitchen bench is now probably enough to deter him, whether it's powered or not.

The Nick-Off version

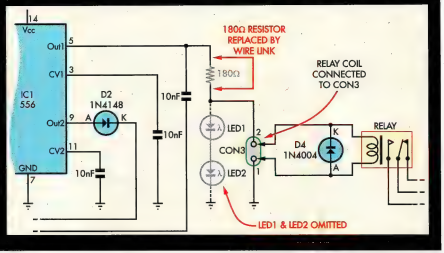
For the version described here, we decided to do away with the messy transistor circuit which admittedly had a few whiskers on it (pun intended). Instead, our resident genius Nicholas Vinen came up with a new circuit based on a dual-timer IC and designed a PCB to make the assembly easy.

The result is the "Nick-Off", a more generic name than "Ted-Off". In reality, the Nick-Off is Ted-Off Mk.2 and it's built into the original Ted-Off biscuit tin. Even the original front-panel label has been retained. We simply

Switching A Relay Output

Normally, you will install either the on-board output LEDs (LED1 & LED2) or wire an external pair of white or blue LEDs to CON3. However, you can also use this circuit to switch a relay which can then turn on a variety of other devices.

Fig.2 shows how this is done. The relay coil voltage should be chosen to match the unit's supply voltage, while the 180Ω series resistor from pin 5 of IC1 is replaced with a wire link. The additional diode is required to absorb any back-EMF from the relay coil when it is de-energised (you may be able to solder this diode across the pads for LEDs1 & 2).



removed the original transistor circuit and installed the new (and improved) circuit in its place.

As with the original circuit, the Nick-Off processes the output from a PIR sensor and generates a brief (about 100ms) low-going pulse to trigger an answering machine (or you could trigger the Digital Sound Effects Module described last month). It also has a second output to drive the two high-brightness LEDs (the dog's eyes) for a period that's adjustable anywhere between a fraction of a second up to about 60 seconds.

This output could also be used to trigger a buzzer or a relay, or some other low-voltage device (see panel).

The Nick-Off also features an exit delay, something lacking on the original Ted-Off. This exit delay is normally around 30s but is less than this (about 10s) if the device is switched off and then immediately switched on again.

In addition, the Nick-Off caters for both NC (normally closed) and NO (normally open) sensors, whereas the original transistor circuit worked with NC sensors only.

Circuit description

Take a look at now at Fig.1 which shows the circuit diagram. It's based on IC1, a 556 dual timer IC.

The PIR sensor is wired to 4-way terminal block CON1, at left. This provides power to the PIR from pins 1 & 4, while the PIR's output relay contacts are connected to pins 2 & 3. When triggered, the PIR activates IC1 which in turn drives the white LEDs and activates the answering machine (via Mosfet Q1).

The PIR signal is AC-coupled to IC1 via a 10nF capacitor and a 1MΩ pull-up resistor, so that the trigger pulse is kept short (about 50ms). This ensures that IC1 is not immediately re-triggered if the PIR stays on for the entire duration of the timing period (eg, if there is constant motion in front of the sensor). Instead, IC1 can only be retriggered by a new event after it has timed out.

Some PIRs have normally open (NO) contacts, which close when activated by motion, but most have normally closed (NC) contacts which open when motion is detected. In addition, a few PIRs have both NO and NC contacts available. Our circuit caters for both types of contacts using links LK1-LK4 and two 10kΩ resistors. One of these resistors acts as a pull-up, while the other acts as a pull-down.

Links LK1 & LK3 are installed for PIRs with NC contacts. This means that the lefthand side of the 10nF capacitor is normally pulled up to the positive supply rail (Vcc) via LK3, the closed relay contacts and LK1. However, when the contacts open (ie, movement is detected), this side of the 10nF capacitor is pulled down via LK3 and the lower 10kΩ resistor, thereby generating a brief pulse and triggering IC1.

Conversely, for a PIR with NO relay outputs, links LK2 & LK4 are installed. The lefthand side of the 10nF capacitor is then normally pulled high via LK2 and the upper 10kΩ resistor. When motion is detected and the contacts close, this side of the capacitor is pulled down via LK2, the relay contacts and LK4, again generating a brief pulse that triggers IC1.

IC1 is configured as two monostable pulse generators but let's initially concentrate on timer 1. When this is triggered, its pin 5 output (Out1) goes high, supplying power to two white LEDs (LED1 & LED2) via a 180Ω current-limiting resistor. The duration that they are lit for is set by 500kΩ trimpot VR1 and a 100µF timing capacitor. VR1 allows this duration to be set anywhere from a fraction of a second up to about one minute.

LEDs1 & 2 are high-brightness 5mm white LEDs and the 180Ω series resistor limits the current through them to (12V - 2 x 3.3V) ÷ 180Ω = 30mA (assuming a 12V supply). This will vary depending on the supply voltage and the forward voltage of these LEDs. It's obviously lower for a 9V supply, although the LEDs will still be quite bright.

To prevent the timer from being triggered when you first apply power to the unit, the reset input (pin 4) of timer 1 is initially held low via a 100µF capacitor. This then slowly charges via a 10MΩ resistor and the reset is subsequently released (goes high) about 30s after power is applied. This provides the "exit delay".

When the unit is switched off, the 100µF reset capacitor quickly discharges via diode D3 so that the exit delay operates if the unit is quickly switched on again. Note, however, that D3 only initially discharges this capacitor down to about 0.5V. IC1's reset threshold is around 0.7V so if the unit is switched off and then immediately switched on again, the exit delay will be shorter than usual (about 10s).

Triggering sound

The second half (timer 2) of IC1 is

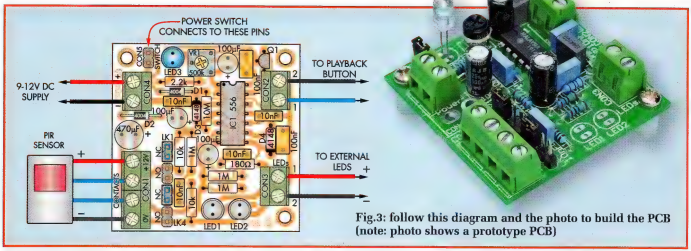


Fig.3: follow this diagram and the photo to build the PCB (note: photo shows a prototype PCB)

Specifications

- Power Supply: 9-12V DC
- Exit Delay: 30s (less if unit is switched off and on again quickly)
- Can be triggered by both NC & NO contacts on alarm sensors
- 100ms pulse output to trigger an answering machine or sound module
- Second output to drive high-brightness LEDs (or some other load) for up to 60s (adjustable)

used to generate a short pulse to trigger a telephone answering machine. As shown on Fig.1, connector CON2 is wired to the trigger input of the sound playback device. Pin 1 of this connector is briefly pulled low when a sound is to be played.

For our prototype, we wired CON2 across the playback pushbutton of a telephone answering machine. However, we could have just as easily used the Sound Effects Generator module described in September 2012, which also has open-collector compatible trigger inputs by default.

In operation, timer 2 in IC1 is triggered by timer 1. It works like this: when the pin 5 output of IC1 goes high to drive the white LEDs, a positive-going pulse is also AC-coupled to the threshold pin (pin 12) of timer 2, again via a 10nF capacitor and a 1MΩ resistor. Normally, a 556 (or a 555) timer is triggered using a negative-going pulse but it's also possible to use a positive trigger by simply swapping the trigger and threshold pins (pins 8 & 12).

In this case, the output sense is inverted and the timing capacitor (100nF) is normally charged and discharges while the timer is active (rather than the reverse situation).

Timer 1 is used to trigger timer 2 so that the latter can't be re-triggered until timer 1 has reset. This ensures that, provided VR1 is suitably adjusted to set the period of timer 1, a second trigger event cannot cancel or restart the playback, especially if the playback period is quite long.

In practice, it's just a matter of adjusting VR1 so that the white LEDs are on for longer than the sound playback period.

The main wrinkle with the configuration of timer 2 is that there is no dedicated pin to recharge the timing capacitor. However, that's easily solved with the addition of diode D4, which allows the timing capacitor to charge directly from the timer output at pin 9 (which is high when the timer is reset). In this case, the timing capacitor is 100nF and the discharge resistor is 1MΩ, giving a time constant very close to 100ms (0.1s).

When the circuit is first powered up, the 100nF timing capacitor is initially discharged and so trigger pin Trig2 (pin 8) is initially low. This effectively resets the timer 2 and its output at pin 9 goes high, which is its quiescent state. When timer 2 is triggered (ie, by timer 1), its output goes low but more importantly, so does its discharge pin (pin 13). This pin is used as an open-collector output to trigger the playback device.

Mosfet Q1

There is a bit of a problem with this scheme, though. While the timer is set up to be immediately triggered, during power-up and power-down when the supply voltage is very low (<3V), IC1 is automatically reset by its internal circuitry. At this time, the discharge pin (pin 13) sinks current regardless

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	3	1MΩ	brown black green brown	brown black black yellow brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown

Connecting The Message Button In The Answering Machine

THE ANSWERING machine is connected via a 2-wire cable that's wired across the message button and runs back to the Nick-Off via a 3.5mm mono jack plug.

You will have to split the case of the answering machine in order to get at the message button. That's normally done by undoing a few self-tapping screws. In our case, we also removed one of the telephone sockets at the rear of the machine (since this was no longer required) and fed the 2-wire cable in through the vacant hole.

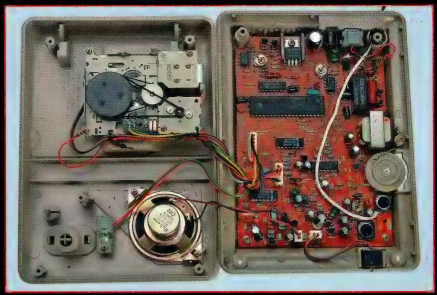
Before wiring in the playback cable, use a DMM to identify which side of the message button connects to ground (0V). This side of the button must be connected to the ground terminal (2) of CON2 in the Nick-Off (ie, via the ground side of the jack socket). This is shown in Fig.2 as the black wire on CON2.

The other side of the button goes to terminal 1 of CON2 in the Nick-Off (blue wire).

In our case, the ground wire running into the answering machine was soldered to a ground stake that was already present on the PCB at the rear of the machine. The other wire was run to the front of the answering machine and soldered directly to one of the message switch contacts on the top of the board.

In some answering machines though, it may be necessary to remove the PCB in order to get at the switch contacts. If so, it's usually just a matter of removing a few more self-tapping screws.

Make sure you correctly identify the switch contacts – the ground contact must run back to the ground in the Nick-Off. If you get the wires mixed up, you could damage the answering machine's playback circuit.



of the state of the trigger and threshold inputs. As a result, we have added Mosfet Q1 between the discharge pin and playback button connector (CON2) to prevent false triggering.

This works as follows. First, LED3 acts as both a power indicator and as a simple shunt regulator. It is a blue LED and so has a typical forward voltage of 3-3.6V. Its anode is connected to the positive supply rail and its cathode to the gate of Q1, as well as its 2.2kΩ current-limiting resistor.

Q1 needs a gate voltage of around 1-2V above its source in order to switch on. This means that it remains off until the supply voltage rises to about 3.3V + 1V = 4.3V. It's also off if the supply voltage falls below 4.3V (ie, during switch-off). This prevents false triggering when power is applied or removed.

Note that if you change the colour of LED3 to a type which has a lower forward voltage (eg, green, red, yellow or orange), then Mosfet Q1 may turn on prematurely and you could get false triggering at power-up and/or power-down. The same comment applies if LED3 is disconnected or not installed, so don't leave this part out of circuit.

Supply components

IC1's two control voltage terminals (CV1 and CV2) have the recommended 10nF bypass capacitors. These filter IC1's internal 2/3 supply voltage dividers, giving it better rejection of supply voltage variations.

Diode D1 provides reverse supply polarity protection for the timer circuit. The resulting supply rail is then filtered using a 100µF capacitor.

Diode D2 serves two purposes. First, it provides reverse polarity protection for the supply to the PIR sensor and second, it isolates this supply from the timer supply rail. As a result, at switch-off, the supply rail to the PIR is maintained for longer than the supply rail to IC1. This prevents the relay contacts in the PIR sensor from opening prematurely and false triggering the timer circuit and thus the answering machine (assuming that it has an NC output).

Because of D2, the PIR's supply rail will be about 0.7V less than the external supply voltage. However, this shouldn't be an issue.

CON5 is a 2-pin header that's wired in series with the external supply. It can either be fitted with a jumper link so that the circuit is permanently powered or wired to an external power switch. The power supply is fed in via 2-way terminal block CON4.

PCB assembly

Take a look now at Figs.3 & 4 for the assembly details. All the parts, with the possible exception of the LEDs and power switch, are mounted on a small PCB coded 03110121.

There are a few options when it comes to the PCB assembly. First of all, you can either mount LEDs1 & 2 directly on the board or you can mount them externally (ie, connect them in series) and run flying leads back to screw terminal block CON3. Similarly, power indicator LED3 can either be mounted directly on the PCB or connected via flying leads.

There are also several power switch

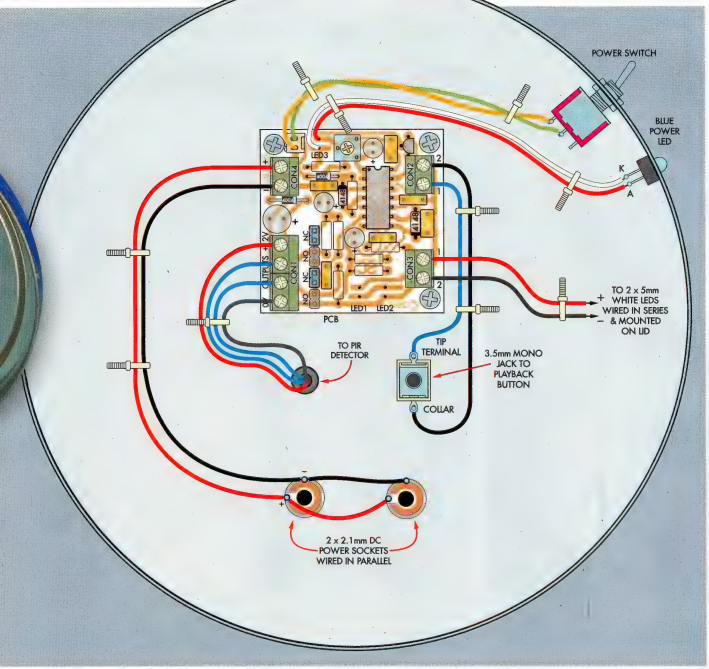
There's plenty of room inside the tin to accommodate all the bits. Note the old doorstop sitting in the bottom of the tin – it's full of old nuts and bolts and acts as a weight to provide stability.

The four leads from the PIR sensor are fed in through a hole drilled in the back of the tin. A P-clamp keeps the wiring in place.

Fig.4: the Nick-Off PCB is installed in a biscuit tin and wired up as shown in the diagram at right. Be sure to use a blue LED for the power indicator, as this is necessary to ensure correct operation of Mosfet Q1.

options. If you don't need an on/off (power) switch, you can simply install a wire link in place of CON5 or you can fit a 2-way pin header and install a jumper link. Conversely, if you do need an on/off switch, then it's simply a matter of connecting it via flying leads, either via a female header or by soldering the switch leads to the header pins.

No particular order need be followed with the PCB assembly, although it's best to start with the low-profile parts (resistors and diodes) first and finish with the connectors. Take care with the orientation of the IC, diodes, LEDs and electrolytic capacitors and leave



the LEDs off the board if you intend mounting them externally.

A 2-way pin header (similar to CON5) can be substituted for LED3 to make any external wiring connections to this LED easier. Do not leave LED3 out and be sure to use a blue LED.

Note particularly the orientation of IC1. It must be installed with its notched end towards VR1. It can be soldered directly to the PCB, or you can mount it via a socket if you wish.

Once the PCB has been assembled, you need to fit jumpers to the LK1-LK4 positions to suit your PIR detector. If the detector has NC (normally closed) contacts, then fit jumpers to the two NC pin headers (LK1 & LK3). Conversely, if your PIR has NO (normally open) contacts, fit the jumpers to the NO headers (LK2 & LK4).

Note that some PIR sensors have both NC and NO contacts available. The NC contacts open when movement is detected, while the NO contacts close when movement is detected. In that case, it's just a matter of choosing either contact set and installing the LK1-LK4 jumpers accordingly.

Housing it

As stated earlier, the original Ted-Off (now the Nick-Off) was built into a biscuit tin, with the bulldog artwork mounted on the lid. This not only maintains a kitchen theme but also saves you forking out extra dollars for a case. That's assuming, of course, that you already have a biscuit tin and have eaten all the biscuits.

The biscuit tin used for the prototype measures 190mm in diameter, which is pretty much standard. The size isn't critical – just as long you can get all the bits in.

An inverted plastic dinner plate (as used for barbecues) was used for the base. Anything around 160-170mm diameter is suitable and it's secured to the bottom edge of the biscuit tin via three M3 x 15mm machine screws

Preventing False Triggering When The Unit Is Switched Off

VIRTUALLY ALL PIR sensors have an NC (normally-closed) output in the quiescent state. This output is usually provided by a relay that's energised to close a pair of contacts when the PIR sensor is powered but no movement is detected.

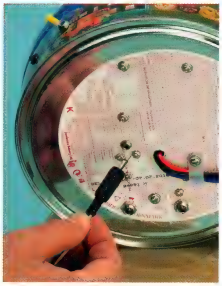
This scheme is employed to help make the sensor tamper proof. If the power supply to the sensor is cut, the relay opens and triggers an alarm module, just as if movement had been detected.

One problem we encountered in developing this unit was that the answering machine (which was separately powered) false-triggered whenever the Nick-Off was switched off. The reason for this was simple: when we cut the power to the Nick-Off and thus to the PIR sensor, the relay in the sensor immediately opened its contacts. This was then detected as a valid trigger pulse by IC1 which had yet to completely power down (the 100µF supply bypass capacitor takes time to discharge). As a result, the timer generated an output pulse which triggered the answering machine.

We overcame that problem by isolating the supply rail to the PIR sensor using diode D2 and then bypassing this rail with a 470µF capacitor. That way, after switch-off, the supply rail to the PIR sensor remains intact for a period that's long enough for the timer circuit to power down, ie, before the relay contacts eventually open.

If you find that your unit still false triggers, it's just a matter of reducing the 100µF bypass capacitor between D1's cathode and ground, eg, to 47µF or 22µF.

Alternatively, in some cases, you might want to keep the PIR sensor permanently powered and just switch the timer circuitry on and off. That can be done by simply connecting the positive supply lead from the PIR sensor direct to pin 1 of CON4 or to the supply side of the power switch.



The PIR sensor is attached to the side of the tin using hook and loop material (Velcro), while the rubber foot stops it from rotating. At the rear, the cable from the answering machine is connected via a 3.5mm jack plug and socket.

arranged in a tripod formation (two at the front and one centred between them at the back). You will need to use a couple of M3 nuts as spacers on the two front screws to compensate for the curvature of the tin.

The bulldog artwork (available on the SILICON CHIP website) is secured to the lid using double-sided tape, after which two 5mm holes are drilled through the dog's eyes to accommodate the external white LEDs. On the prototype, these were secured in place using neutral-cure silicone sealant. Alternatively, you can make the holes slightly larger and secure the LEDs using plastic mounting bezels.

Fig.4 shows the wiring details. The PCB was mounted on three M3 x 10mm tapped Nylon spacers and it's simply a matter of drilling matching holes through the base (rear) of the tin. In addition, you have to mount a 3.5mm mono jack socket (to plug in the cable from the answering machine) and two 2.1mm panel-mount DC sockets towards the bottom.

The DC sockets are wired in parallel to provide power "pass-through". That way, you can use the answering machine plugpack (provided it's rated at 9-12V DC) to power both the Nick-Off and the answering machine. You will have to make up a cable fitted with DC plugs at both ends to connect the answering machine to one of these sockets.

Well, that's the theory anyway. On the prototype, it didn't quite work out that way because the answering machine plugpack couldn't supply the necessary juice to power both the answering machine and the Nick-Off. The extra current required by the PIR sensor, particularly when activated, was probably the main culprit here.

As a result, the prototype Nick-Off had to be powered by a separate 9V DC plugpack.

Mounting the PIR sensor

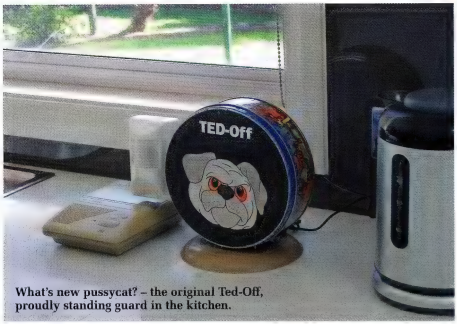
As shown in the photos, the PIR sensor is secured to the lefthand side of the tin using hook and loop material, eg, Velcro (available from hardware stores). This consists of two 15mm-diameter pads, one attached to the side of the tin and the other to the side of the sensor.

In addition, a rubber foot is secured to the side of the tin about 50mm away from the pad, using an M3 x 10mm machine screw nut and washer. This foot provides a "rest" for the bottom righthand edge of the sensor and ensures that it stays upright. Without this rest, the sensor tends to rotate (or "sag") anticlockwise.

The four wires from the PIR sensor are fed in via a hole drilled in the rear of the tin and are connected to CON1. Alternatively, the PIR can be permanently powered by connecting its positive supply lead direct to the supply side of the power switch.

Testing

Once the assembly is complete, apply power (without the answering machine connected) and check that



What's new pussycat? – the original Ted-Off, proudly standing guard in the kitchen.

the blue power LED lights. The two white LEDs (LEDs 1 & 2) should be off at this stage.

If the power LED doesn't light, check the supply polarity and that D1 and LED3 are correctly orientated.

Assuming that all is correct, switch off and check that you have the correct linking options for LK1-LK4. In most cases, you will need to install links in the NC positions (ie, LK1 & LK3) if you are using a PIR sensor.

That done, reapply power and wait for the exit delay (up to 30s) to expire. **In addition, PIR sensors require a warm-up period of up to two minutes before they start working, so you will have to wait this period out if it's longer than the exit delay.**

Once the PIR sensor is operational, move in front of it so that it triggers and check that the two white LEDs immediately light up. These should then stay on for a preset period (up to 60s), depending on the setting of VR1. Adjust VR1 to suit your particular application.

Finally, plug in the answering machine, switch it on and re-trigger the PIR. The two LEDs should again immediately light up and the answering machine should trigger and play back the recorded message (or barking).

If that all works, the Nick-Off is ready for action and can be set on the kitchen bench to watch out for errant puddy tats. And that is the end of this tail . . . err, tale. SC

Parts List

1 PCB, code 03110121, 50 x 50mm
5 2-way mini terminal blocks, 5/5.08mm pitch (CON1-4)
5 2-way pin headers, 2.54mm pitch (LK1-LK4, CON5)
3 shorting blocks
1 500kΩ mini horizontal trimpot
1 2-way header plug, 2.54mm pitch (CON5) (optional)

Semiconductors
1 556 dual timer IC (IC1)
1 2N7000 Mosfet (Q1)
2 1N4004 diodes (D1, D2)
2 1N4148 diodes (D3, D4)
2 white high-brightness 5mm LEDs (LED1, LED2)
1 blue 5mm LED (LED3)

Capacitors
1 470µF 16V electrolytic
3 100µF 16V electrolytic
2 100nF MKT/MMC
4 10nF MKT/MMC

Resistors (0.25W, 5%)
1 10MΩ
3 1MΩ
2 10kΩ
1 2.2kΩ
1 180Ω

Extra Parts For Nick-Off

1 telephone answering-machine or electronically-triggered sound generator module
1 9-12V 300mA DC plugpack
1 PIR sensor (9-12V)
1 biscuit tin, 190mm diameter
1 plastic dinner plate, 160mm diameter (approx.)
1 front panel artwork (available from **siliconchip.com.au**)
1 chassis-mount toggle switch
2 2.1mm panel-mount DC sockets
1 3.5mm mono jack socket & plug
3 5mm plastic LED bezels
1 Nylon P-clamp, 5mm
3 M3 x 10mm tapped Nylon spacers
1 rubber foot (screw-mount)
Hook & loop material (15mm-dia. pads)
6 small cable ties
1 M4 x 10mm machine screw
1 M4 nut
1 M4 flat washer
3 M3 x 15mm machine screws
1 M3 x 10mm machine screw
6 M3 x 6mm machine screws
8 M3 nuts
8 M3 flat washers
3 300mm lengths of medium-duty hook-up wire (red, black & blue)

PRODUCT SHOWCASE

LED cabinet lights from Ocean Controls

These flat strip lights now available from Ocean Controls use small LEDs to produce an even illumination with low power consumption. The included low-profile mounting clips allow installation in tight spaces for workspace illumination, bookcase lighting, architectural lighting or product showcases.

The flat strip has a profile only 8mm thick and 33mm wide and is available in 30, 50 and 100cm lengths. Using connectors or corner pieces the lights can be easily daisy-chained together to produce an extra long light, or a square or rectangular-shaped light.

A 12V DC or 24V DC plug pack (not included) can be used to power the lights. The 12V DC or 24V DC supply mean they are also ideal for automotive, caravan and camping applications. These flat strips are compatible with Ocean Controls dimmer, inline switch, PIR sensor and 4 way splitters. They're priced from $23.95 +GST.

Contact:
Ocean Controls
PO Box 2191, Seaford BC, VIC 3198
Tel: 03 9782 5882 **Fax:** 03 9782 5517
Website: www.oceancontrols.com.au

New overmoulds from Clarke & Severn

Clarke & Severn Electronics (CSE) have announced the latest overmould options for the EN3 line of products by Switchcraft. The three new EN3 options have a rugged construction, more slim-line style and excellent flex relief, making these overmolded connectors perfect for harsh environments. They are available in straight, right angle and quick connect.

The CSE Straight Overmold is produced locally at CSE's Hornsby Heights (NSW) plant. Using the innovative Macromelt Moulding they can supply small volumes, providing a fast turnaround time and low minimum order quantities of 20 cables per contact size.

The Right Angle Overmold and the EN3 Quick Disconnect Overmold, which quickly snaps into place again and again, while providing a watertight seal, are produced by Switchcraft in USA. EN3 Overmoulds are ideal for mobile equipment, such as monitoring equipment or outdoor lighting.

Contact:
Clarke & Severn Electronics
PO Box 1, Hornsby NSW 2077
Tel: 02 9482 1944 **Fax:** 02 0482 1309
Website: www.clarke.com.au

A FREE MULTIMETER from Altronics stores!

Everyone in electronics knows about Altronics' superb mail order and online service – but did you know that Altronics now have four retail stores – one each in Sydney (Auburn) and Melbourne (Springvale), their long-established Perth city store and a new one in Balcatta (Perth northern suburbs).

To introduce their retail stores to **SILICON CHIP** readers, if you call in to any store this month and make a purchase (any purchase – even a resistor!) and mention '**SILICON CHIP**', you'll receive a **FREE** 19-range digital multimeter.

You'll have to be quick though, Altronics have secured just 200 per store and once they run out, you miss out! (Offer is limited to one per customer and is only available from Altronics stores directly [not via resellers or online purchases]).

Wiltronics appointed as new Australian PICAXE distributor

Revolution Education Ltd, the UK developer of PICAXE products, has appointed Wiltronics Research Pty Ltd as an Australian Distributor for their range.

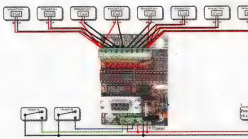
Wiltronics, based in Ballarat, Vic, has been in business for 38 years and is a major supplier in the education sector, distributing a large range of science and technology products Australia wide.

Wiltronics operates under an ISO9000 accredited Quality Management System and is focused on a high level of customer service.

The company has an extensive range of products, including a large range of PICAXE, all available online.

Contact:
Wiltronics Research Pty Ltd
PO Box 4043, Alfredton Vic 3350
Tel: 03 5334 2513 **Fax:** 03 5334 1845
Website: www.wiltronics.com.au

Robotic and sound systems for animation control



Providing quality equipment to the broadcast and AV market in Australia for over 25 years, EAV Technology have recently introduced Gilderfluke robotics and sound systems into their product range.

Gilderfluke & Co. designs and manufactures Animation Control Systems and CD- Quality Digital Audio Repeaters.

These are used by theme parks, museums, waterparks, miniature golf courses and other attractions throughout the world.

All of the Gilderfluke systems are modular, so off-the-shelf components can be plugged together to fit any job.

Many Gilderfluke products are utilised by Stage One Productions in the construction of the Melbourne Myer windows Christmas displays, including the MiniBrick8 as the controller for the movement of the reindeer in this animated show.

Outputs can also be used to trigger Digital Audio Repeaters, DVDs and other serially controlled devices (through a BR-SDC), or anything else which needs to be controlled. All of the Gilderfluke systems support storage of at least 255 shows at the same time.

Gilderfluke provide modular components that include pneumatic & hydrolic controls, relay & switch outputs, audio / video & lighting controls, and more.

From constructing your own digital signage, to creating a fountain and light show, Gilderfluke have the components for a wide range of applications.

Contact:
EAV Technology
284 Wingrove St, Fairfield Vic 3078
Tel: 03 9489 0010 **Fax**: 039489 0030
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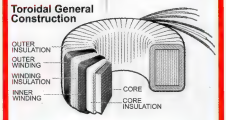

Comprehensive data available:
www.harbuch.com.au

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9/40 Leighton Pl, HORNSBY 2077
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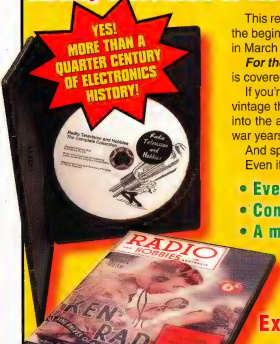

This remarkable collection of PDFs ***covers every issue*** of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to EA.

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If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. If you're a student of history, this archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years.

And speaking of the war years, R & H had some of the best propaganda imaginable! Even if you're just an electronics dabbler, there's something here to interest you.

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Now with 100-pin micro & Arduino connector

Pt.2: By GEOFF GRAHAM

The COLOUR MAXIMITE

Building the unit and using its new sound & colour features

Last month, we introduced the Colour Maximite, an inexpensive computer with colour VGA output, keyboard input and an SD card for storage. We now take you through construction and provide a brief run-down on how to use its new features.

IN DESIGNING THE Colour Maximite, we have been careful to specify parts that can be easily sourced. So if you want to "go it alone" without a kit, that option is always open to you. The two custom parts, the PCB and a programmed PIC32 chip, can be purchased directly from the SILICON CHIP Partshop.

Alternatively, if you want to source the PIC32 chip yourself, you must also have access to a suitable programmer. In that case, the PIC32 chip can be purchased direct from Microchip, Element14 or some other supplier. You must be careful to choose the correct part number as there are two 100-pin packages, one measuring 12 x 12mm and the other 14 x 14mm. We designed the PCB to suit the latter, to make it easier to solder, so be sure to purchase the 14 x 14mm package (with the /PF suffix), as specified in the parts list.

The SD card connector is a little more difficult. Every manufacturer seems to have their own footprint for this connector. We designed the PCB so that it could accommodate a number of different footprints but we have only tested the Hirose DM1A connector which is reasonably popular and available from Element14 and others.

The high-density VGA connector is also available in a number of different footprints so we have selected the most popular. This version has an overall depth of 22mm from front to back.

The 10µF SMD capacitor connected to pin 85 of the PIC32 must be a ceramic type. Don't try to substitute a tantalum or (heaven forbid) an electrolytic here, as this component is critical to ensure that the PIC32's CPU starts and runs correctly.

As mentioned last month, regulator REG2 (TC1262) was selected for its low drop-out voltage and accuracy. You can substitute another device with the same pin-out but you should ensure that it has a drop-out voltage of 0.8V or less, otherwise the Colour Maximite could intermittently crash.

Construction

Take a look now at Fig.4 for the PCB assembly details. It's quite straightforward and should only take a couple of hours to build.

It's best to start with the microcontroller (IC1) which is a surface-mount

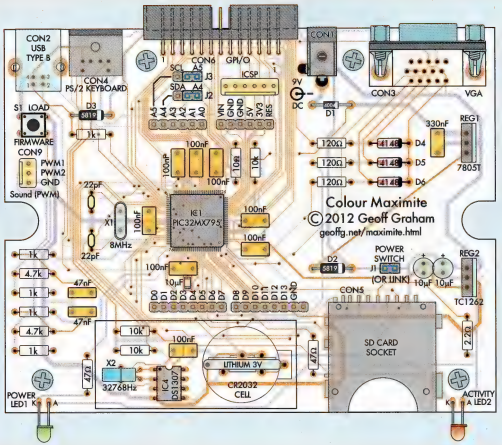


Fig.4: follow this PCB parts layout diagram to build the Colour Maximite. The PCB is screen-printed so you can also follow that to help place the components. Note that this diagram also includes the parts placement for the optional battery-backed clock. Begin the assembly by installing the PIC32 micro and make sure that all polarised parts are correctly orientated.

device. This might sound daunting but it is relatively easy to solder. Even better, if you've bought a kit, the PCB may come with the chip already soldered in place, so you don't have to do that job.

We have described how to solder SMD chips many times in the past and we won't repeat that in any great detail here. The important factor is that, in addition to a temperature-controlled soldering iron, you also need a good liquid flux designed for SMD work, a pair of fine-tipped tweezers and a magnifying glass (or magnifying lamp).

If you are new to soldering SMD devices you can watch an excellent tutorial on this subject at: **http://store.curiousinventor.com/guides/Surface_Mount_Soldering/101** You can also refer to pages 80-82 of the June 2012 issue of SILICON CHIP for a detailed description on soldering in SMDs ICs.

In any case, the basic technique is as follows. First, carefully place IC1 on its pads, with its bevelled corner (adjacent to pin 1) at bottom right. That done, apply plenty of flux and solder one corner pin. Then, after checking the chip's alignment, solder the opposite pin.

It's now just a matter of steadily moving around the chip and soldering the remaining pins, applying additional flux as you go. Use only a tiny amount of solder when soldering each pin, to avoid solder bridges. If you do get a bridge, ignore it and carry on, as you can come back later and remove it using solder wick.

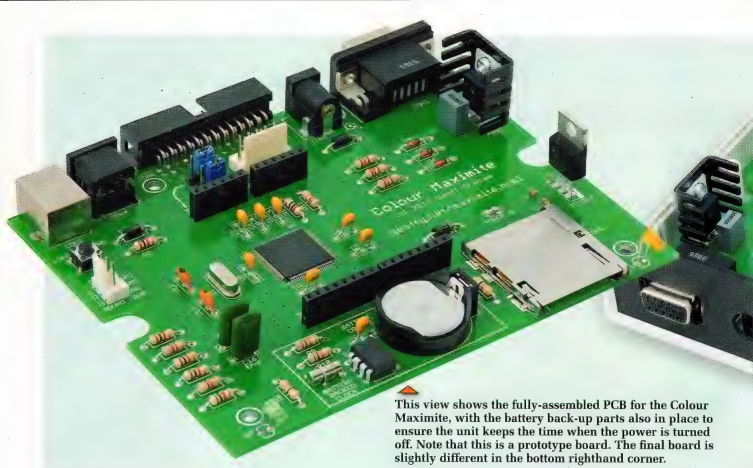
The important factor is the flux. Use plenty of it before you apply the sol-

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
330nF	0.33µF	330n	334
100nF	0.1µF	100n	104
47nF	0.047µF	47n	473
22pF	NA	22p	22

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	5	1kΩ	brown black red brown	brown black black brown brown
❑	3	120Ω	brown red brown brown	brown red black black brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	2.2Ω	red red gold brown	red red black silver brown



This view shows the fully-assembled PCB for the Colour Maximite, with the battery back-up parts also in place to ensure the unit keeps the time when the power is turned off. Note that this is a prototype board. The final board is slightly different in the bottom righthand corner.

dering iron to each pin and the solder will flow quickly and easily. For this job, flux is your friend and too much solder is the enemy.

Finally, use a magnifying glass and a good light to carefully inspect the chip, to ensure that all the pins have been correctly soldered and that there are no bridges remaining.

Once the PIC32 chip is in place, the remaining parts can be installed according to Fig.4 and the screen-printed labelling on the PCB. Start with the low-profile components (resistors and diodes) and work up to the taller items like the voltage regulators, the pin headers and the sockets. Be sure to install the diodes, regulators and electrolytic capacitors with the correct orientation.

The SD-card socket specified is a surface-mount part. It has two small posts on the underside and these go into two matching holes in the PCB to ensure that the socket is correctly positioned. Once it's in place, it's a matter of locating and soldering all the tabs; there are 15 in total, including some for the body of the connector.

In particular, two tiny tabs on the left hand side of the socket (viewed from the front) are not very obvious. They are used to detect when a card is inserted or is write-protected, so do not miss them.

It's best to leave the two LEDs until last. LED1 (green) is installed at front left, while LED2 (orange) goes to the right. To fit them, first bend each LED's leads down through 90° immediately adjacent to its body, with its long lead (anode) on the right when looking at the lens from the front. That done, trim their leads to about 14mm long, then temporarily mount the PCB and front panel in the case.

The two LEDs can now be fitted in position, so that they poke through their holes in the front panel. Their leads are then tack-soldered to the top pads on the PCB, after which you can remove the PCB and complete the soldering on the underside.

Optional power switch

Pin header J1 (marked on the board as POWER SWITCH) is for an optional power switch. Normally, you would simply fit a jumper to this header to short it out (or install a wire link). However, we provided this facility in case you wanted to wire in a front-panel switch, so that you can turn the Colour Maximite on and off just like a big computer.

Basically, a power switch is up to you. The Colour Maximite uses so little power (approximately 160mA) that even if you left it turned on 24 hours a day, it would only consume an additional $2 worth on electricity in a year (less than the cost of a switch).

The 5V regulator (REG1) should be fitted with a small heatsink (type 6073) to dissipate the heat when the power supply exceeds 12V. The 3.3V regulator (REG2) dissipates much less heat and doesn't need a heatsink.

Once the PCB has been completed, it can be installed in the case and secured using four No.4 x 9mm self-tapping screws. These go into integral spacers on the base of the case. That done, you can connect the stereo audio (or PWM output) from polarised header connector CON9 to a 3.5mm panel-mount phono socket on the rear panel. The photographs and Fig.5 show the details for the connecting cable.

Programming the PIC32

If you either purchased a kit or purchased the PIC32 chip from SILICON

The PCB is secured inside the case using four self-tapping screws that go into integral pillars in the base.

CHIP, you can skip this section as the micro will already be programmed. If not, you will need to solder a 6-pin polarised header connector in the ICSP (CON7) position on the PCB, as shown on Fig.4.

After that, it's just a matter of connecting your programmer to this header and programming the chip with the firmware (available from the SILICON CHIP website).

You need the ***ColourMM_plus_bootloader_V4.0.hex*** file, where 4.0 is the firmware version number.

This version of the firmware includes a bootloader which is a small section of code that allows you to later update the firmware over the USB interface. With software of this complexity, it's virtually impossible to avoid bugs and when these are found and fixed, the author will create an updated version of the firmware which will be available at **http://geoffg.net/maximite.html#Downloads**

The update will contain all the necessary software and instructions

Testing

Testing the Maximite is as simple as plugging it into a 9V DC power supply (normally a plugpack) and switching on. Note that the power provided by PCs on their USB ports can be unreliable, so the initial testing should be done using a plugpack.

On power up, the firmware will run a self-test and after this has successfully completed it will turn on the green power LED on the front panel. An illuminated LED is therefore an indication that all is OK, while no light means that you have a problem.

If the LED doesn't come on, you should first check the power supply voltages. The supply voltage should be 7-16V, while REG1's output should be 5V and REG2's output should be at 3.3V. If these voltages are correct, you should then check all the capacitors for correct placement, value and polarity. Every one is critical and a misplaced capacitor could prevent the processor from starting up.

Check also that the power LED is correctly orientated and that its associated 47Ω resistor is correct. The LED will not light if it is installed the wrong way around or a high-value resistor has been installed.

The final check is to examine IC1 for shorts or defects in soldering. This will

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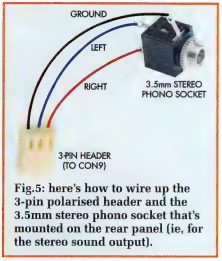
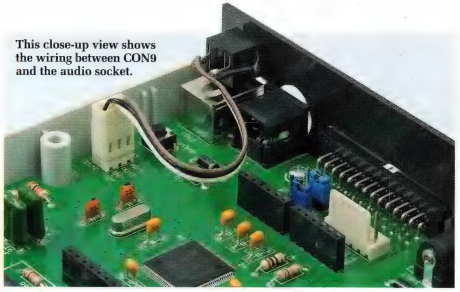


Fig.5: here's how to wire up the 3-pin polarised header and the 3.5mm stereo phono socket that's mounted on the rear panel (ie, for the stereo sound output).



This close-up view shows the wiring between CON9 and the audio socket.

require a high-powered magnifying glass and you should carefully check each pin.

With the firmware running, you can check the video output by attaching a VGA monitor – you should see the MMBasic prompt in full colour. Finally, plug in a PS/2 keyboard and try typing something in. With the firmware running correctly, any faults in these interfaces can only be related to components specific to those interfaces. As such, they should be easy to diagnose – it's basically a matter of checking the parts and/or the PCB tracks between the relevant connector and the micro.

Note that when displaying white characters on a black background, the text may not appear to be as sharp as with the monochrome Maximite (it is still very good though). This effect depends on the VGA monitor and (if it occurs) is caused by slight timing variations between the three colours as the video is clocked out of the SPI channels.

Back-up clock assembly

Installing the additional parts for the battery-backed clock is straightforward. Fig.4 shows the details.

There are two options here: you can either use a cell holder and a 3V LiMn coin cell (see photos), or you can use a cell with solder tabs. The PCB layout accommodates both options.

When you first power up the Colour Maximite, the firmware will recognise that the clock is installed and will display a message under the Maximite logo saying that the clock is not set. To set it, you use the standard commands in MMBasic for setting the time:

TIME$ = "hh:mm"
DATE$ = "dd/mm/yy"

where *hh* is the hours (in 24-hour notation) and *mm* is the minutes when setting the time. Similarly, *dd* is the day, *mm* is the month and *yy* is the year when setting the date.

That should then be the last time for a long period that you have to use these commands. From then on, MMBasic will automatically retrieve the current time and date on power-up and display it under the Maximite logo – just to let you know that your battery-backed clock is working correctly.

This is the startup screen that you can expect to see when you power up your Colour Maximite. You can see just under the logo where MMBasic has found the optional battery-backed clock and retrieved the current time.

Using the Arduino connector

The designations for the Arduino pins are screen-printed on the PCB and follow the standard layout. These pins include both +5V and +3.3V supply rails which you can use for your circuit up to 150mA in total (ie, combined). Other pins give you access to the input power supply voltage and allow you to reset the PIC32 processor.

Many Arduino systems make the I^2C signals available on connector pins A4 and A5. We have therefore provided two jumpers (J2 and J3) so that you can select between the normal I/O function for these pins (A4 and A5) or the I^2C signals (SDA and SCL).

Note that these two I^2C signals are shared with external I/O pins 12 & 13 on the rear panel (see Fig.9) and so are

also connected to the Arduino header when selected by jumpers J2 & J3.

Other than that, the Arduino connector works as usual. The I/O pins can be controlled from within MMBasic using the designations D0-D13 and A0-A5, as marked on the PCB. These input/outputs are independent of the I/Os on the back panel.

For example, to get the input voltage on A3, the MMBasic command would be: **Volts = PIN(A3)**

The analog pins (A0-A5) have an input range of 0-3.3V, while the digital pins will accept input voltages up to 5V. The output from all pins is 0V at logic 0 and 3.3V at logic 1.

Serial port COM2 is available on D0 and D1, as is common with Arduino boards. Again note that the output is 3.3V while the inputs can be up to 5V.

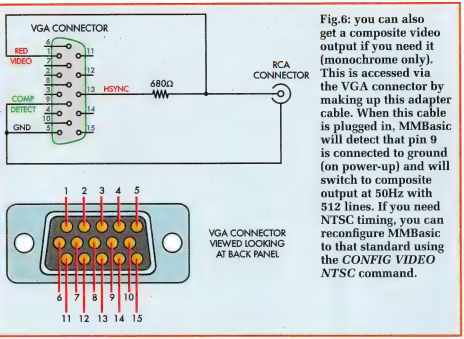


Fig.6: you can also get a composite video output if you need it (monochrome only). This is accessed via the VGA connector by making up this adapter cable. When this cable is plugged in, MMBasic will detect that pin 9 is connected to ground (on power-up) and will switch to composite output at 50Hz with 512 lines. If you need NTSC timing, you can reconfigure MMBasic to that standard using the *CONFIG VIDEO NTSC* command.

USB Interface

The USB interface allows you to connect the Colour Maximite to your desktop or laptop computer so that you can enter text without having to connect a VGA monitor and keyboard to the Maximite itself. Anything you send over the USB will be interpreted as keystrokes by MMBasic and any output from MMBasic will be sent back via the USB.

Before using the USB interface, you need to install the Silicon Chip USB Serial Port Driver on your computer (available from the Silicon Chip website). This will work with all modern versions of Windows and full instructions are included with the driver. The standard CDC protocol is used and drivers are included as standard in the Mac and Linux operating systems.

The Colour Maximite will be listed in the Device Manager on your Windows PC under Ports (COM and LPT). It will appear as "Communications Port – Silicon Chip USB Serial Port", with a specific COM port number. When you configure the serial emulation software on your computer, you will need to specify this number to establish communications with the Maximite. If the software also needs to know the communications parameters, you should specify 9600 baud, one stop bit and no parity.

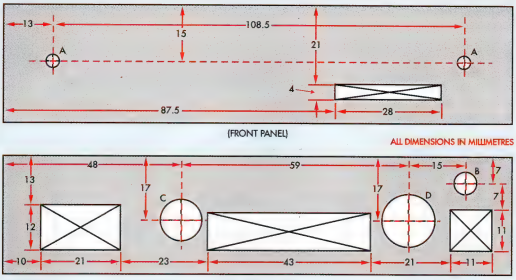
For Windows, we recommend that you use the free, open source Tera Term (**http://logmett.com**) for the serial emulation software. This emulator works with the XMODEM command in MMBasic for transferring files and also with the full-screen editor in MMBasic. You can also copy and paste text from Windows into Tera Term and then transfer it to the Maximite. For this to work, you need to configure Tera Term for a delay of 50ms per line (Settings –> Serial Port).

Working with Colour

The Colour Maximite produces eight colours, including black and white. Previous versions of MMBasic already had the facility to select the colour (which could be black or white) when drawing graphics. The major difference is that you can now also specify the colour as red, yellow, green and so on.

The colour is specified as a keyword or number. So, for example, to draw

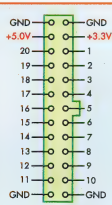
A great feature of the Colour Maximite is that it will accept Arduino "shields" that plug into matching connectors on the Maximite's PCB. The above photo shows an example of an Arduino compatible breadboard. Prototyping boards like this make it easy to add some special circuitry to the Colour Maximite.



HOLES A: 3.5mm DIAMETER; HOLE B: 6mm DIAMETER; HOLE C: 11mm DIAMETER; HOLE D: 14mm DIAMETER

Fig.7: these diagrams show the front and rear panel cutouts for the Colour Maximite. The position of most cutouts is critical, as the associated components are soldered to the PCB. Before starting on the cutouts, check their position and size against the actual components that you are using, as their footprints (and size) can vary between manufacturers.

Fig.8: the front panel artwork can be copied onto adhesive paper and then covered with a thin adhesive plastic sheet or sealed with a heat laminator. It's available in PDF format from the SILICON CHIP website.



INPUT/OUTPUT PIN CONNECTIONS

Fig.9: this diagram shows the pin designations of the external I/O connector as viewed from outside the case. The pin numbers are used in MMBasic when you want to configure and use the I/O pins. The 5V and 3.3V outputs are for powering other circuits (150mA total current drain).

a red circle you would use the command:

CIRCLE (x, y), RED

where x and y are the coordinates of the circle's centre.

You could also use the number "4" instead of the keyword RED but the keyword makes the program easier to read. There are eight colour keywords: BLACK, BLUE, GREEN, CYAN, RED, PURPLE, YELLOW and WHITE, corresponding to the numbers 0-7.

As another example, the following will set a pixel to yellow:

PIXEL(x, y) = YELLOW

Many commands allow you to use a default colour, primarily the PRINT command which always uses the default output colour. You can specify this default with the COLOUR command. For example:

COLOUR GREEN

Following this, all graphics that do not specify a colour will be outputted in green.

The **COLOUR** command also allows you to specify the background colour. For example:

COLOUR PURPLE, YELLOW

will print text in purple with a yellow background (ughh!). Note that, to cater for our American readers, you can also use the command **COLOR**.

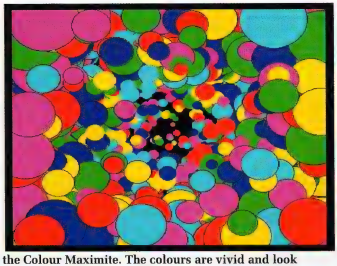
Embedding colour commands

To make text more colourful, MMBasic allows you to embed colour commands into text strings using the CLR$() function. When you embed this function in a string, it will instruct the PRINT command to select a specific colour for the following text.

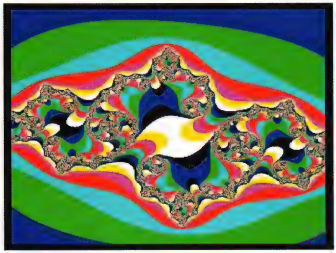
For example, this will print the word "cat" in blue:

PRINT "My fluffy " CLR$(BLUE) "cat"

The full syntax for the function is: *CLR$(foreground, background)*. As you can see, you can set the background colour with the optional second argument. For example, this



These two screen grabs show two colour patterns generated by the Colour Maximite. The colours are vivid and look stunning (the CMYK reproductions shown here don't do them justice). The program used to generate this output is available from the SILICON CHIP website and when you run it, you will also appreciate that the output is animated.



This screen grab shows the Julia set generated by the Colour Maximite. The Julia set is mathematically similar to the more famous Mandelbrot set and the program to create this image was written by Rob (loki) on the Back Shed forum. It's included in the software files available on the SILICON CHIP website.

will print yellow letters on a red background:

PRINT CLR$(YELLOW, RED) "ALARM"

The colours are reset to the defaults (set by the COLOUR command) when the print command terminates.

Colour modes

As explained Pt.1, generating eight colours uses up some of the CPU's capacity and memory. By reducing the number of colours, you can increase the speed and the amount of free memory available.

To allow you to make this trade-off, we created the MODE command in MMBasic. This command controls how the Colour Maximite generates colours and it can be used to select one of four different colour modes ranging from 1-4.

MODE 1 is the monochrome mode. In this mode, the Colour Maximite operates the same as the monochrome Maximite, with the same performance and the same amount of free memory.

A second argument can be used to select the colour of the monochrome output. For example, the following will set the monochrome output to green:

MODE 1, GREEN

MODE 2 is the 4-colour mode. In this mode, four colours (including black) are available. The four colours available are selected by a number from 1-6 in the second argument of the MODE command (the palette).

This mode is half-way between monochrome and the full 8-colour mode in its use of the CPU and memory.

MODE 3 is the 8-colour mode and is the default at power up. This uses the most memory but there's still plenty left for programs and data.

Finally, *MODE 4* is provided for games and the like that need all eight colours but also require better performance than is available when using *MODE 3*.

In *MODE 4*, the display is switched to 240 x 216 pixels and because there are less pixels to draw, screen writes are much faster. This lower resolution also requires less memory, so the programmer has the maximum amount of free memory for loading fonts, playing music and so on.

You can switch between all four colour modes while your program is running and the switch is instantaneous. This allows you to tune the display and performance to your requirements at any time.

Stereo audio

A new feature of the Colour Maximite is that it will play synthesised music and sound effects – and in full stereo too. This implementation was created by Pascal Piazzalunga, a Maximite fan who lives in France.

You start the music playing with the command:

PLAYMOD filename, playtime

The first argument is the name of a music or sound effects file, while the second is the length of time that the file will be played. If the latter is not specified, the file will play continuously until specifically told to stop or the program ends.

Once started, the synthesised audio will play in the background. This means that your program will continue running and executing commands without interrupting the music.

For performance reasons the file

This view (without the rear panel) shows how the two LEDs and the SD-card socket are fitted to the PCB. Note that this version simply uses a link in place of the power switch and doesn't include the optional battery back-up components or the audio cable which runs from CON9 to the off-board stereo phono socket.

must reside on the internal flash drive created by MMBasic (drive A:). The music must also be in the *MOD* format. This format originated from the Amiga systems of the late 1980s. It is not a recording of the music (like an MP3 file) but instead contains instructions for synthesising the music.

On the original Amiga, the task of decoding the instructions contained in the file and synthesising the music was performed by dedicated hardware. It is a tribute to the power of the PIC32 chip and the software written by Pascal Piazzalunga that it can perform the same synthesis in software while simultaneously generating colour VGA, running a BASIC program, communicating via USB and performing many other tasks.

There is an entire subculture based around this format (and similar formats) that is part of what is called the "demoscene". But you do not have to worry about joining that scene because there are many thousands of music tracks that you can easily find on the Internet. One of the largest libraries is at: **http://modarchive.org**

You can also create your own music using a program called a "tracker". This is a music sequencer that allows the user to arrange notes on a timeline across several channels. An example of a tracker can be found at **http://www.modplug.com**

Tone output

If you need to just create a simple sound, you can use the **TONE** command, which is also new in version 4.0 of MMBasic. This will generate a single-frequency tone that is a pure sinewave.

You can specify different frequencies for each stereo channel in the range of 1Hz to 20kHz, with a resolution of 1Hz. Each frequency is locked to the PIC32's crystal oscillator, so it will be very accurate. As with the music created by the **PLAYMOD** command, the sinewave is synthesised in software.

Normally, this feature would be used to make a simple beep sound but with the two channels joined together using a simple resistive mixer, you could, for example, generate DTMF tones. Another use is as an accurate audio signal generator for testing amplifiers and loudspeakers.

Other features

The Colour Maximite has many other features that we have not covered here (the magazine does not have enough pages!). These include multiple communications protocols, loadable fonts, full-screen editor, an internal flash file system, advanced programming features, a sprite engine and more.

The MMBasic User Manual, available for download from the SILICON CHIP website, now runs to 55 pages. So if you want to get the most from your Colour Maximite you have some serious reading ahead of you.

If you have the original Maximite, you can get many of the features described above by upgrading your firmware to version 4.0. Your Maximite will not be able to generate colour but you can play music and sound effects (in mono), generate tones and more using this version.

For updates and construction hints for all Maximites go to **http://geoffg.net/maximite.html** SC

Repeated from Pt.1, this rear view shows (from left to right) the VGA socket, the DC power socket, the multi-way I/O connector, the keyboard socket and the audio and USB sockets. The unit is powered from either a 9V plugpack (or battery) or from a USB port on a PC.

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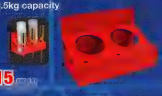

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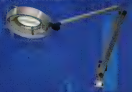

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Adding a wireless remote control to the BARKING DOG BLASTER

by Ross Tester

There's a couple of pooches next door that really do have me barking mad. They start yapping at the drop of a hat and to make matters worse, their idiot owner howls and woofs at them . . . which of course sets them off even more.

So when John Clarke came up with his new Barking Dog Blaster last month, I couldn't wait to try it out!

And guess what? It seems to work!

Of course, nothing stops them when stupid is goading them. But at other times, if they start barking and I can race over and hit the "start" button quickly enough, more often than not they cease with the racket and look around to see where that infernal noise (to them!) is coming from.

Mr Pavlov, you might just have been on the right track!

Well, so far so good. But (isn't there always a but?) the delay in getting up, going across to the start button and pushing it quite often meant that the barking had ceased of its own accord.

This started me thinking, what if it could be triggered automatically – for example, put a microphone and amplifier in it so then when it sensed a bark, it fought back.

However, when I discussed this with John he told me he was one step ahead of me – in fact, earlier versions of this device used exactly that idea.

The downside was that any loud noise would trigger it – neighbourhood kids, traffic, low-flying aircraft, thunder, you name it – and the at-the-time-non-barking dog in question would be somewhat confused by the screech from the speakers – was it directed at him or wasn't it? Scratch that idea.

OK, if we couldn't have it automatic, what about reducing the time between bark and blast, some sort of remote switch, which could be kept within easy reach, ready to hit on the first bark?

This idea had merit – so much so that we actually promised it at the end of the article in September (boy is that dangerous!).

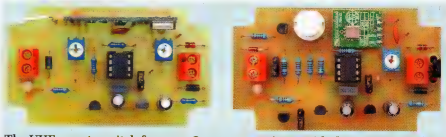
But in this case we figured it couldn't be too hard – and so it proved.

Which remote switch?

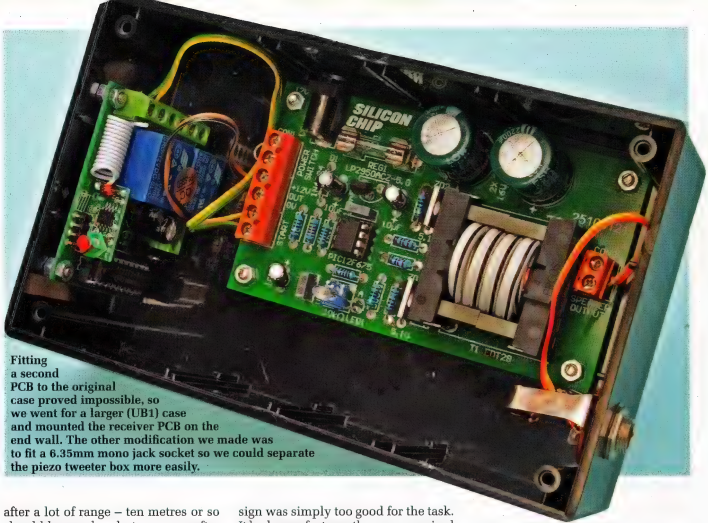
The wireless switch simply replaces the push-button switch of the original article. Or, if you wish, can be wired in parallel with that switch. One will not affect the other.

The choice is basically between an infrared remote switch or a wireless (radio) remote switch.

We've described numerous versions of both in SILICON CHIP. We weren't



The UHF remote switch from our January 2009 issue with the receiver on the left and transmitter on the right. While still practical (and available from Jaycar as a kit), for this project it's perhaps *too* clever.



Fitting a second PCB to the original case proved impossible, so we went for a larger (UB1) case and mounted the receiver PCB on the end wall. The other modification we made was to fit a 6.35mm mono jack socket so we could separate the piezo tweeter box more easily.

after a lot of range – ten metres or so should be ample – but we were after more than line-of-sight.

So that pretty-much ruled out infrared – they don't work around corners too well!

We then went back to radio-based wireless remote controls and found several to choose from. The most recent was one described in the January 2009 issue – a 433MHz UHF Remote Switch (again from the fertile brain of John Clarke).

It looked like it would do the job – in fact, it certainly would – and we even went to the extent of arranging a kit from Jaycar Electronics.

But on closer examination, this design was simply too good for the task. It had more features than was required for a task as simple as this. Was there a simpler route?

Then we recalled an advert from Kitstop in the August 2012 issue (page 6), featuring a small, simple 433MHz keychain transmitter and matching receiver, already built and tested, for less than $30.00.

While it had two channels (we only needed one) it otherwise appeared to be exactly what we wanted so we obtained a set from Kitstop (**www.kitstop.com.au**; cat no KSRC2) – and this article is the outcome.

Of course, if you want the thrill of building your own remote switch there is nothing to stop you doing so (Jaycar Cat No KC5473). Indeed, the case we've chosen will (just!) fit the January '09 receiver PCB in the end (in the same position as the Kitstop receiver shown in the photo above).

The alternative KSRC2 transmitter/receiver pair from Kitstop (www.kitstop.com.au). It's prebuilt into the bargain – so you can't go wrong!

Identify the terminals

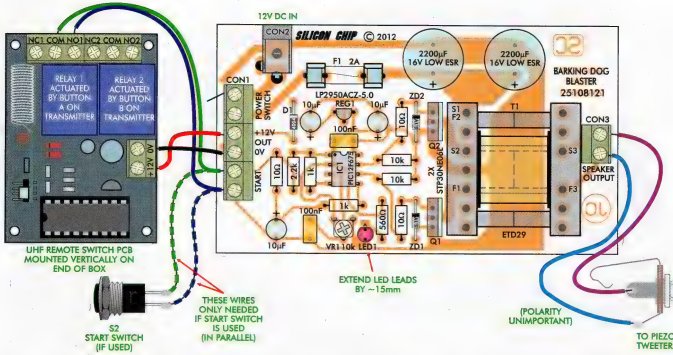
If you're using the Kitstop module, there are two things you need to confirm – first that the transmitter is set up to talk to the receiver and second, which terminals to use.

Because both transmitter and receiver are pre-assembled and tested, it's almost certain that the first will be OK as supplied.

But just in case, (eg, if you have reason to change coding because of interference) Kitstop include details of how to change the coding on both transmitter and receiver.

As far as the terminals are concerned, normally, button "A" on the transmitter fires the receiver's "1" relay contacts. It holds the relay in while ever the button is pressed – exactly what we are after.

Before putting the receiver module



There's no circuit diagram (it's in last month's issue) – simply add the receiver module as shown here. We've shown the Kitstop KSRC2 module; using the January 2009 design is similarly mounted (albeit a tighter fit). We've "opened out" this diagram for simplicity – the receiver module actually mounts vertically on the end wall of the UB1 box, with the 6.35mm socket on the opposite end wall, as shown overleaf. The larger front panel can be downloaded from siliconchip.com.au.

in the box, connect it to 12V and press a transmitter button – each button should make its associated relay pull in (you'll hear the click).

The Barking Dog Blaster is switched by the "NO" and "COM" contacts – you might like to confirm with a multimeter that they are only closed when the button is pressed.

Putting it together

With the extra PCB (whether it's the Kitstop prebuilt or the Jaycar kit) the project will not fit inside the original (UB3) case.

So we went up to the UB1 case – it's 158 x 95 x 53mm so there is tons of space within the case, as you can see from the photo. A new, larger, front panel label was also prepared.

The start switch was originally wired to the bottom two terminals on CON2 (they're labelled "start") while 12V power for the receiver PCB is available the next two terminals up (thoughtfully labelled +12V and 0V out).

As the Kitstop receiver PCB has a standby current of 13mA, you might want to fit a power switch to the top pair of terminals, especially if you are running the unit from a 12V battery.

In this case, the link between the top two terminals would be removed and replaced by wires to the power switch. That switch could be accommodated anywhere convenient on the front panel.

The other modification we made to the original circuit was to connect a 6.35mm mono jack socket to the transformer output (CON1). This was done simply for convenience – it's so much easier to be able to disconnect the driver unit from the speaker array.

Position is unimportant, as long as it clears the components on the PCB and also allows the lid to be fixed in place.

Naturally, this also required fitting a 6.35mm mono jack plug to the speaker wires!

PCB location is not overly critical but it makes sense to keep the receiver PCB away from the transformer.

We used the PCB itself as a template to drill the four holes for its mounting screws, placed the PCB in position in the case then carefully marked the horizontal position of the hole for the 12V DC input plug.

The vertical position for this hole was 38mm down from the top of the case (ie, without lid). It's easier to measure down from the top as you have a definite edge to measure from.

One minor problem is LED height – in the deeper box, even soldered with as much lead as possible, the LED top is still about 15mm or so below the panel, so you need to mount the LED on a pair of 15mm long wires. In fact, you might find it easier to mount the LED in a bezel on the lid and use flying leads (eg a pair of wires from rainbow cable) to connect to the PCB.

Wiring

Wiring the rest of the project is quite simple – just follow the diagram.

It's difficult (if not impossible) to connect your wiring to the receiver PCB terminals with it mounted in place (the terminals are horizontal and difficult to access), so you will need to connect its wiring first. Wiring to the Blaster PCB is easy because the terminal screws all face to the top.

Once completed, attach four small self-adhesive feet to the underside of the box to prevent the screw-heads scratching any surface the unit is placed on. In the absence of rubber feet, four dobs of silicone sealant a little higher than screw-head height will do.

You'll find complete setup and troubleshooting details in last month's article so we won't go over old ground here. Just remember, anything that the pushbutton switch referred to in that article will do, the remote switch will also do. SC

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There's a handy order form on P97

MICRONIX MSA 3.3GHz Spectrum A

This portable/hand-held instrument can run from mains or for up to four hours on an optional Lithium-ion battery. It has multiple measurement modes, USB flash drive support, PC connectivity (also USB) and an automatic signal finder mode. Its average noise level is -127dBm.

The **MSA438** is a capable spectrum analyser in a compact package. Its 14cm (5.7") 640x480 pixel LCD displays a clear and uncluttered frequency domain plot and it is controlled using 22 pushbuttons and a jog wheel.

The unit weighs 1.8kg so it can be operated hand-held – even with one hand, although we wouldn't want to hold it like that all day. It's 162 x 265 x 71mm which is large for a hand-held instrument but manageable enough. There is a fold-out stand on the back for desk-top use.

The unit is easy to drive and it only takes a few minutes to get the hang of its interface, which like many instruments these days is based on a set of six "soft buttons" below the LCD. There is also a numeric keypad for quick frequency entry or you can use the jog wheel for fine adjustments.

The signal input is an N-connector (50Ω) and there is also an SMA input for external triggering.

It has an "auto tune" mode, but this will not make you a pop music sensation! Rather, it searches for the strongest signal in the current frequency span and sets the unit up to focus on it. In manual mode, you can have it automatically adjust parameters such as resolution bandwidth (RBW), sweep time and so on or you can specify them yourself.

The unit has two USB sockets. One is for a flash drive, which can be used to store screenshots, captured data (as comma-separated variables) and configuration data. The other connects to a computer and in combination with software sold separately, can be used to drive the unit. With a computer, you can get a higher resolution spectrum, 1000 pixels wide rather than 500.

With the optional battery, operating time is stated as four hours but that's with the LCD backlight off which is only useful if it's plugged into a computer. With the backlight on, battery life is more like 2-3 hours.

When it runs low, you get a series of increasingly urgent warning beeps before the unit cuts out.

One quirk of the MSA438 is that you can't charge the battery while using the unit. Presumably that's because the mains adaptor "brick" doesn't have the herbs.

Spectrum analysis

Now, let's look at the kind of analysis you can do with this unit. The frequency span can be set anywhere from 200kHz to the full 3.3GHz in a 1-2-5 pattern. The resolution bandwidth can be set from 3kHz to 3MHz in a 1-3 pattern (ie, 3kHz, 10kHz, 30kHz, ...).

This controls how clearly the separate frequency peaks are defined. The centre frequency is set in 20kHz steps, using the keypad or jog wheel as explained earlier.

The display shows ten frequency divisions (horizontal) and ten power divisions (vertical); the latter are normally 10dB/div for a maximum range of 100dB. You can also set it to 5dB/div and 2dB/div. The vertical scale can be offset, with the top of the display being between +10dBm to -60dBm. Vertical units can be read out in dBm, dBµV, dBmV or dBV.

Once you have selected a frequency and span, you can set the resolution bandwidth. The practical lower limit depends on the span selected. With the default sweep rate, 3kHz RBW is usable with a span of up to 500kHz, 10kHz RBW up to about 5MHz span, 30kHz RBW up to 50MHz span and 100kHz RBW up to 2GHz span. If you set RBW to "auto", it changes as you adjust the span.

If you need a faster (or slower) update rate than normal, you can manually adjust the sweep rate. The results won't necessarily be accurate but it's a good way to search for a signal; you can then slow the sweep down to get more accurate results once you've found it.

The actual dynamic range, ie, the difference between the strongest signal displayed and the noise floor depends on the resolution bandwidth and reference level selected.

The best results are achieved with a fine resolution bandwidth and low reference level (ie, with the input attenuator set at minimum attenuation).

The stated figure of -127dBm at 1GHz is achievable and even with wider spans, if you don't mind a longer sweep time, the noise floor is generally below -115dBm.

There's also a Video Bandwidth setting which can be used to further reduce noise at the expense of resolution. Its range is 100Hz-1MHz in a 1-3 pattern.

The user manual contains a series of specifications detailing the guaranteed accuracy under a number of different conditions.

Over much of the available range, readings are within about ±1dB and ±0.3MHz but this varies with the centre frequency, span, power level,

438 analyser

Review by Nicholas Vinen

Running off its batteries, the MSA438 is displaying the spectrum of an FM radio station being picked up by a small wire antenna (not visible). The vertical blue bars indicate that the Adjacent Channel Power Ratio is being calculated for the stations's sidebands. The current settings are shown down the left side of the screen while the soft buttons and measurement read-outs are along the bottom.

resolution bandwidth and so on. If you're using the unit with a combination of settings where accuracy isn't guaranteed, a red "UNCAL" warning appears in the upper-left corner of the screen.

Measurement modes

The MSA438 can make a number of useful measurements derived from the spectrum analysis. These include channel power, adjacent channel power ratio, occupied bandwidth and electric and magnetic field strength (with accessory probes). These are all intuitive to use and what you are measuring is displayed graphically, along with the result.

You can also control how the data is processed before display with four modes: maximum hold, minimum hold, averaging and "overwriting" mode, which is a form of brightness-based scatterplot that lets you capture the power distribution over a span of time.

In each case, the number of spectra analysed can be set to between 2 and 1024, after which the unit automatically goes into "hold" mode (or you can set it to run continuously).

The MSA438 has support for one or two markers. One is normally placed atop the highest peak although you can also define a frequency band for it to search within. You can then move the marker to the next highest peak, etc, and you can read out the frequency and power at the marker in dBm or Watts.

The second marker is used for relative measurements. You can also move the markers manually, using the jog wheel.

The frequency and power of the highest peak is always displayed, regardless of whether any markers are enabled.

Additional features

As mentioned earlier, you can save the spectrum data to a CSV file. You can also save the spectrum display or the whole screen to a bitmap (BMP) image on the USB flash drive.

There are three different colour schemes available for the display, including two high-contrast black-on-white schemes (one of which is pure monochrome). These make it easier to read the screen in direct sunlight compared to the default yellow-on-black scheme, which is better for indoor viewing.

The unit is supplied with a carrying case which protects it from knocks and bumps (it is portable, after all). It also comes with a mains adaptor and user manual.

Several optional accessories are available including probes to measure electric and magnetic field strength, PC software to interface with the unit, various antennas, a USB printer, the aforementioned frequency counter and the battery plus a number of attenuators, terminators, cables and adaptors.

Conclusion

The MSA438 is a portable spectrum analyser which is easy to use and has good performance plus a number of handy features. If 3.3GHz isn't enough for you, there is also an 8.5GHz model (MSA458). Or you can get the 3.3GHz model with a tracking generator output (MSA438TG) or EMI test features (MSA438E).

To make an enquiry or purchase, contact Vicom on 1300 360 251, visit www.vicom.com.au or e-mail info@vicom.com.au

Vintage Radio

By Rodney Champness, VK3UG

The Philips twins: the Dutch BX462A & the Australian model 115

It's not common to see two sets that look almost identical on the outside but which are completely different on the inside. Such is the case with the Philips BX462A (Dutch) and 115 (Australian) receivers. In fact, the closer one looks at the chassis of these two sets, the more the differences become apparent.

BACK IN THE JUNE 2012 issue, Vintage Radio ran a story on John de Haas and his collection of Dutch and Australian vintage receivers. This month, we take a look at two receivers from his collection, the Dutch Philips BX462A from 1946 and the Australian Philips 115 from 1948.

These two sets are built into cabinets that are, to all intents and purposes, the same. Apparently, Philips Australia obtained the mould pattern for the cabinet of the slightly earlier European receiver and then designed and fitted a chassis to suit the Australian market.

From the outside, the most obvious differences between these two sets concern the dial-scale markings. For Australia, the dial scale is calibrated for the 530-1620kHz broadcast band only, whilst the Dutch version carries markings for a triple-band receiver. That's because in addition its broadcast band (536-1765kHz) facility, the BX462A is also capable of long-wave (150-424kHz) and shortwave (5.8-18.5MHz) reception.

Another external difference involves the number of controls. The Dutch version has two controls on the righthand side of the cabinet for tuning and band-switching, while the lefthand side carries an on-off/volume control and a tone control. By contrast, the Australian 115 carries just the tuning control on the righthand side, with the volume and on-off/tone controls on the left.

Their perforated cardboard rear panels are also different (although, unfortunately, the rear panel is now missing from the 115 set in John's collection). As shown in one of the photos, the Dutch BX462A also carries a number of diagrams which indicate the functions of the various chassis-mounted sockets, which are accessible through

matching cut-outs in the rear panel.

An interesting feature of the BX462A is that the power lead must be unplugged before the rear panel can be removed. This provides protection against electrocution – at least until the power lead is reconnected. In this set, there are a number of exposed connections on the power transformer along the back edge of the chassis, near the mains plug. By contrast, the AC power connections are better protected against accidental contact in the Australian 115.

In fact, Australian manufacturers generally provided better protection against accidental contact with high voltages compared to most European receivers.

Another interesting feature of the BX462A's rear panel is that a large section of the inside surface is lined with foil. This is connected to the receiver's antenna terminal when the rear panel is in place and can be used as the sole antenna in strong reception areas. The Australian 115 set has a similar foil antenna, although this is glued to the underside of the top of the cabinet (see photo).

Different valve counts

Once the rear panel is removed, it's immediately obvious that the BX462A is a 4-valve receiver only, although it has a 3-gang tuning capacitor which means that the circuitry must be something special (more on this later). By contrast, the 115 has five valves and a 2-gang tuning capacitor. It's a fairly standard mains-operated receiver as we shall see.

When restoring vintage radio receivers, it's common practice to remove the chassis from the cabinet. However, John de Haas strongly advises against doing this in the case of the BX462A unless it's absolutely imperative. That's because the dial tuning mechanism is complex, difficult to get at and has to be dismantled before the chassis can be removed, as it is attached to the rear of the front panel.

The 115 poses no such problems. Its dial-drive mechanism is attached to the chassis, so the latter can be removed quite easily. The speaker is attached to the front panel but it's simply a matter of unplugging its leads from the chassis as the latter is slid out of the cabinet.

The BX462A's speaker is also attached to the front panel. This arrangement gives better baffling than in many other receivers. The glass dial-scales sit proud of the cabinet in both sets and before doing any serious work on either receiver they should be removed so that they don't get broken. They are held in place with spring-loaded clamps just below the cabinet top and are straightforward to remove.

They may look the same on the outside but they use completely different chassis as these inside views of the Philips BX462A (top) and 115 receivers show. The Australian 115 covers the broadcast band only while the Dutch BX462A is a 3-band receiver and is much more complicated.

As stated above, removing the BX462A's chassis from its cabinet is something to be avoided whenever possible. That's usually not a problem though, because the underside of the chassis can still be accessed, simply by removing the bottom panel. In Philips sets, this bottom panel is usually a cardboard-type material and often has metal foil on its upper side. This acts as a shield for the under-chassis components and is connected to the chassis earth when the panel is in place.

Removing the bottom panels reveals that these two receivers are very different. As mentioned above, the BX462A is a 3-band receiver whereas the 115 is a broadcast-band receiver only. As a result, the BX462A is much more crowded under the chassis, especially around the band-switch. This makes

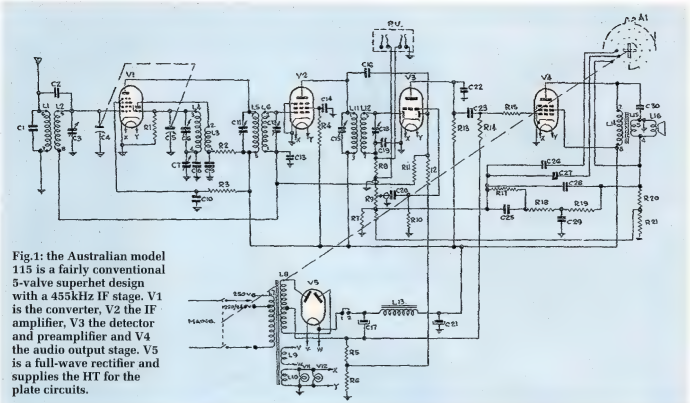


Fig.1: the Australian model 115 is a fairly conventional 5-valve superhet design with a 455kHz IF stage. V1 is the converter, V2 the IF amplifier, V3 the detector and preamplifier and V4 the audio output stage. V5 is a full-wave rectifier and supplies the HT for the plate circuits.

the 115 by far the easier receiver to service.

115 circuit details

Fig.1 shows the circuit of the 115. It's a fairly conventional superhet design apart from some interesting features in the tone control circuit.

The incoming RF signals are picked up by either an external antenna or the foil plate antenna inside the cabinet and fed to a tuned circuit consisting of L1 & C1. This tuned circuit is resonant just below the broadcast band when used with a short antenna. This boosts the performance of the input circuit, enhancing reception at the low-frequency end of the dial.

In addition, capacitor C2 provides a degree of top-coupling, so that the high-frequency stations also get a boost.

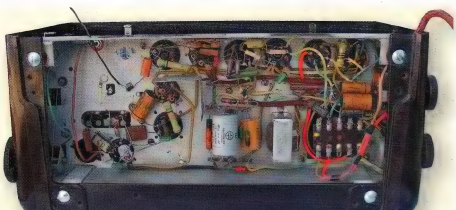
This view shows the Australian model 115. Note the unusual "pop-up" dial scale, a feature it shares with the Dutch BX462A receiver.

From there, the signal is fed via the antenna tuned circuit (L2, C3 & C4) to the grid of V1, an ECH35 converter valve. The oscillator tuned circuit consists of the components around inductors L3 and L4 and the resulting oscillator signal is injected via a grid into the converter section of the valve.

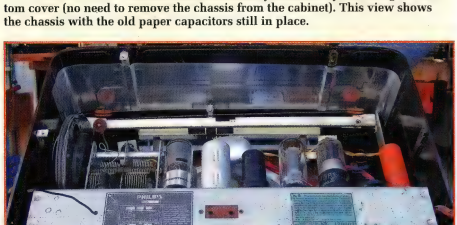
The IF (intermediate frequency) in this set is 455kHz and this component from the converter is fed from the ECH35's plate to the primary of the first IF transformer (L5 and C11). This is then coupled via the IF transformer's secondary (L6 and C12) to the signal grid of valve V2, a 6SK7GT IF amplifier. Its output is in turn fed via a second IF transformer to a detector diode in valve V3 (6SQ7GT), where it is demodulated.

In this set, a metal 6SQ7 has been used and its parameters are virtually identical to the GT version. Another thing to note is that wire-type trimmers are used to adjust the tuned frequency of the IF transformers rather than iron-dust cores. However, once set, they don't tend to drift in value and work just as well as iron-dust cores, although they are more fiddly to adjust.

After detection, the audio signal is applied via an RC network and volume control R9 to the grid of the 6SQ7 (V3). V3 amplifies this signal which is then



The underside of the chassis in the 115 is easily accessed by removing the bottom cover (no need to remove the chassis from the cabinet). This view shows the chassis with the old paper capacitors still in place.



This view inside the model 115 shows how the foil antenna is attached to the inside top of the cabinet.

fed via another RC network to the grid of V4, a 6V6GT audio output stage. In fact, this particular set has a 6V6GTA, which has a slightly different envelope to the GT version.

The amplified signal from V4 drives the loudspeaker via an output transformer.

Note that provision is also made to connect a record player pick-up to the first audio amplifier (V3). When this is connected, the audio from the detector is shorted to earth and the pick-up signal line is isolated from the detector.

The tone control and negative feedback network is quite extensive. It consists of the switch at the top right of the circuit diagram and the following resistors: R7, R17, R18, R19, R20 & R21 and capacitors C25, C26, C27, C28 & C29. It's somewhat reminiscent of the comprehensive tone and negative feedback circuits that were used by Astor.

As well as feeding the second IF stage, V2's plate is connected to the AGC diode in V3 via a 33pF mica capacitor (C16). Normally, V3's AGC diode is biased off by -1.25V of backbias from the power supply (via R12). This voltage is also applied via R11 & C13 to provide the standing bias for both V1 and V2.

When a signal strong enough to generate more than -1.25V DC on the AGC diode is received, the standing bias is exceeded. After that, any further increase in signal level generates a voltage that's then fed to the AGC network. This voltage can increase to -10V or more, depending on the signal strength, and controls the gain of V1 and V2.

The power supply is quite standard and includes a mains transformer with three secondaries: 5V, 6.3V and a centre-tapped HT (high tension) winding. The latter drives a 5Y3GT full-wave rectifier (V5) which in turn supplies approximately 240V DC to the first filter capacitor (C17).

The filtering network consists of two electrolytic capacitors (C17 & C21) and filter choke L13. In addition, resistors R5 and R6 are wired between the centre tap of the HT winding and chassis. The voltage drop across these resistors provides a back bias of -12V for the 6V6GT and -1.25V (at their junction) for the two RF valves (V1 & V2).

Note that there is no decoupling between the plate circuits of any of the valves. Although this works well in most cases, instability can sometimes occur in sets that don't have decoupling between the plate circuit of the output valve and the rest of the circuit. However, this instability will usually only occur in sets with quite high gain.

BX462A circuit details

Fig.2 shows the circuit details of the Dutch BX462A. As can be seen, it's very different to the circuit used in the Australian 115 receiver.

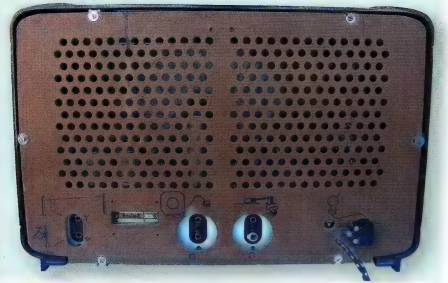
As with the 115, the BX462A also includes a flat-foil antenna, in this case attached to the rear panel. Alternatively, an external antenna can be connected to the antenna terminal.

The antenna tuned circuits are much more complex in the BX462A than in the 115, to cater for the three switched bands: long-wave, medium-wave and shortwave. There is also an additional tuned circuit which operates at the signal frequency on both the long-wave and medium-wave bands, hence the use of a 3-gang tuning capacitor. On shortwave, however, only one antenna tuned circuit is used.

The way Philips has drawn the switches initially makes the switching arrangement hard to follow, although it's quite simple once you've figured out what's going on. After studying the circuit and the Dutch service manual, I've concluded that the extra tuned-frequency selectivity stage is needed on the long-wave and medium-wave bands for two simple reasons.

First, the high-frequency end of the long-wave band is 424kHz, just 28kHz away from the centre of the IF amplifier passband (452kHz in the BX462A). Second, the 530kHz low-frequency end of the broadcast band is only 78kHz away from the IF passband, although this is not as critical.

The signal from the antenna tuned



The rear panel of the Philips BX462A carries diagrams to identify the various sockets, ie, antenna and earth, external loudspeaker and turntable.

circuit is applied to the signal grid of valve B1, an ECH21 triode-heptode converter. The local oscillator is based on the triode section of this valve and its signal output is mixed in the converter section. This is an unusual valve in that the oscillator injection grid in the heptode comes out to a separate pin. This allows the triode and heptode sections to be used for quite different purposes, as in the next couple of stages.

The converter output at the plate of the heptode has several frequencies present but the only one of interest is the IF at 452kHz. This is fed through a double-tuned IF transformer to the signal grid of B2, another ECH21. In this instance, the heptode section acts as a straight pentode and the amplified signal at its plate is fed via another double-tuned IF transformer to the detector diode in B3, an EBL21.

The resulting demodulated audio signal from the detector is amplified in the triode section of B2. The amplified signal (on the plate) is then applied to the grid of valve B3 which now functions a high-gain output pentode. This then drives the loudspeaker via an output transformer.

Negative feedback is applied from the voice coil winding of the output transformer to the input of B3. This feedback circuit is unusual in that it has two inductors in the feedback path. Unfortunately, the values of these inductors are not shown on the circuit or in the parts list.

As with the model 115, the audio amplifier stage in the BX462A includes an input for a record player pick-up. This is connected by inserting a double plug into the socket shown at the top right of the circuit. When this is done, the audio from the detector is shorted out and the pick-up signal is fed to the top of the volume control (R15).

AGC in this receiver is achieved by feeding a high-level IF signal from the plate of the heptode in B2 to the AGC diode in B3 (via C34). The AGC diode is back-biased via R3 and the bias is also applied to the triode audio amplifier grid and the IF amplifier and converter stage grids.

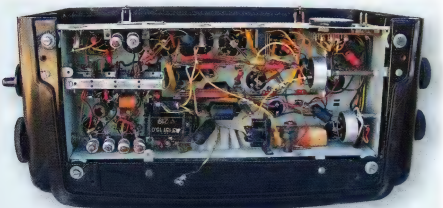
Because the diode is reverse biased, it doesn't conduct until the receiver is tuned to a relatively strong station. Once the back-bias level is exceeded, the diode conducts and the resulting voltage is applied to the AGC line via R22. This bias voltage is filtered by C36.

The power supply transformer has a number of primary winding taps so that the set can work on a variety of mains voltages, ranging from 110V AC to 245V AC. There are three secondary windings: a 4V winding for the rectifier filament, a 6.3V winding for the heaters of the amplifying valves and a centre-tapped HT winding that's fed to rectifier B4, an AZ1.

This arrangement provides about 240V DC at the first filter capacitor (C1). The HT is then applied to a tapping on the audio output transformer which acts in part as a filter choke and provided it's correctly phased, will tend to buck any hum in the grid circuit of the audio output valve.

The other end of this choke is connected to a 1.2kΩ resistor (R1) and is then further filtered using C2 to provide the HT rail for the receiver.

Compared to the 115, this receiver has many more decoupled power supply lines which is good design practice. Back bias is provided for all amplifying stages of the receiver by the voltages developed across resistor R2 (68Ω) and resistor R3 (33Ω). B3 receives about three times as much back-bias voltage as the other two stages.



The underside of the chassis in the BX462A is also accessed by removing the bottom cover. The layout is more crowded than in the model 115 and access to some parts around the band-switch (at left) is not all that easy.

Restoration

To restore these two sets, John replaced all critical and/or leaky paper capacitors, a few out-of-tolerance resistors and any electrolytic capacitors that had gone low in value or had excessive leakage current. Any weak valves were also replaced.

In addition, both cabinets were carefully cleaned and polished and they now look quite attractive. All the wiring in the BX462A appears to have plastic insulation whereas the 115

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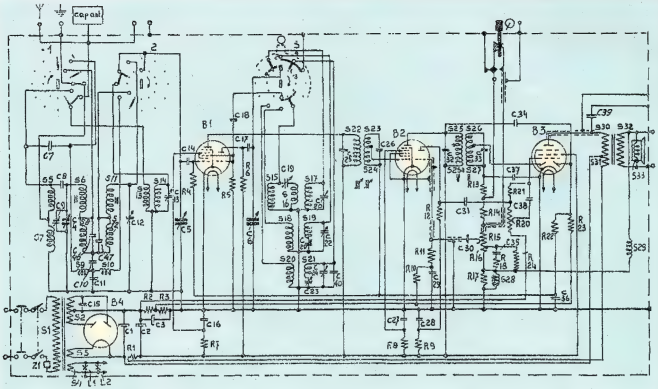

Fig.2: the BX462A is a 4-valve superhet with band-switching to cover the long-wave, medium wave (broadcast) & short-wave bands. A 3-gang tuning capacitor is used to provide for an additional tuned circuit when operating on the long-wave & medium-wave bands, to improve selectivity.

has a number of rubber-covered leads which have perished. These leads haven't been replaced but will need to be if the wiring is later disturbed.

Comparing the two sets

From the outset, it's obvious that the BX462A is a very well-designed set, with no skimping on the parts needed to do a good job. Its part count includes 47 capacitors and 24 resistors, whereas the 115 has 29 capacitors and 21 resistors. In addition, the BX462A has three tuned bands whilst the 115 covers the broadcast band only.

Both sets offer good performance but the BX462A is just that little bit better as more care has been taken in matching the tuned circuits to the valves to achieve the best outcome. The BX462A also has more decoupling between stages which ensures good stability in this high-performance receiver.

That said, both have good negative feedback and tone control networks and both provide good-quality audio when tuned to local stations.

One problem with the BX462A is the poorly thought-out dial scale arrangement, as mentioned earlier. Working on the antenna and oscillator coils in the BX462A wouldn't be easy either. However, Philips coils and IF transformers are generally very reliable, so this usually isn't a problem as the seldom require replacement.

Conclusion

There's no doubt that the BX462A is the superior set, both in terms of its circuit design and performance. It also features long-wave and shortwave bands, which the 115 lacks.

However, the 115 still offers good performance and it is a simpler set which makes it easier to service.

So which of the two would I prefer if I had to choose between them? Definitely the BX462A but I'd also take the 115 home any day if it was offered to me. SC

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LITTLE JIM AM TRANSMITTER	JAN 2006	06101062	$25.00
POCKET TENS UNIT	JAN 2006	11101061	$25.00
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dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11)
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ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

USB recording interface for multi-track use

I have been looking at your "USB Stereo Recording & Playback Interface" (SILICON CHIP, June 2011) and wonder whether there would be any problems if I use it just for the ADC function, ie, input only at S1? This could simplify construction if I omit the microphone preamps. Would it then be sensible to put a volume control at the input? Perhaps 15kΩ pots at the line input would do the job?

I have a very good 8-channel mixer with balanced and stereo line outputs but I would like to run it into a PC. Perhaps SILICON CHIP has done just the A-D bit for that very purpose or would the June 2011 circuit do a better job?

Another question is how can I get multi-track recording on a PC? Can just one USB input, with appropriate software, give me a multi-track outcome in the PC for editing and production? It seems the best way to do multi-track recordings is to use hardware like Zoom R16 etc and then transfer the tracks into the PC for editing (eg, with Reaper etc).

Conceptually, it should be possible to assign each channel of a mixer to a separate track in a PC with a DAC and a USB connection but this would require some kind of "tagging" of each channel in the mixer and separation in the PC. I don't know if anyone does that.

I have been told that the clock for the DAC can be a critical issue for high-end recording. Mention has been made of "jitter" and software (eg, Apogee's "Big Ben") that gets down to just tens of picoseconds of error in clock speed. Apparently (young) audio engineers can hear the difference and look for very accurate control of the DAC.

Can you comment on the accuracy of the clock for the June 2011 DAC? Has SILICON CHIP done an article on a digital audio work-station (DAW), especially on multi-track recording and editing? (J. K., via email).

● If you need only line inputs on the USB Recording & Playback Interface of June 2011, it would be OK to omit all of the mic preamp circuitry. It would also be OK to fit 15kΩ or 10kΩ pots at the line inputs, as you propose. We have not described any other stereo ADC projects which would be more suitable for your application.

For multi-track recording on a PC, you would need a somewhat different set-up. It would be able to use a single USB 2.0 port but the ADC would need to be a specialised multi-channel device which would be able to "tag" the samples for each channel before they are interleaved in the bitstream sent to the PC.

We cannot answer your questions about clock jitter in ADCs and DACs. You'll need to talk to specialists in high-end digital audio processing. We have not produced a digital audio work-station.

More injectors with the Digital Pulse Adjuster

Your Digital Pulse Adjuster (from SILICON CHIP's "Performance Electronics For Cars") will run two fuel injectors, each with a minimum of 10Ω. I'm looking at running four injectors (minimum) by adding another Mosfet (STP16NF06).

The question is, do I need to add or increase the values of diode D1 or the 100nF & 100µF capacitors? (T. E., via email).

● You should not need to use more than one Mosfet if you change it to an IRF1405N. Also change the fuse to 6A and thicken the PCB tracks leading to the Mosfet and diode using solder or tinned copper wire.

In addition, the 100µF capacitor could be replaced with a 220µF low-

Using The Programmable Ignition With A Lumenition System

I have have two questions regarding your Programmable Ignition Module (SILICON CHIP, March-May 2007). Firstly, I have a Lumenition distributor for a Holden V8 but I do not have the ignition module that would normally hook up to the SILICON CHIP unit.

After looking around, I found a page on your website which sounded as though it would answer my question, ie, can I use the distributor as a switch without the ignition module? The answer on the website said that this was covered in the May 1994 issue of the magazine. I bought a copy of that issue but then realised it was referring to an older version of the programmable ignition unit.

So can I use the Lumenition distributor as a switch and a spark distributor (no ignition module)? If so, what modifications do I need to make for it to work? There are three wires that come from the Lumenition switch: blue, black and red.

When using the ignition module in a normal set-up (no programmable ignition), there should be 27V between the blue and black leads when the infrared beam is not interrupted. This drops to 10V when the beam is interrupted. The red wire is approximately 7.5V.

Secondly, where can I obtain a MAP sensor to mount on the circuit board? Do you have any suggestions as to where to find the right type? (M. H., via email).

● The connections required for the Lumenition module are shown in the March 2007 issue, page 26, Fig.6(c). This should be connected to a 12V supply. We are not sure about the 27V you are referring to as a voltage from the module.

Just about any MAP sensor for a car (that operates on 5V) available from an auto wreckers will suit. Our test sensor was from a Holden Commodore.

Displaying Temperatures In An Intercooler

I have built the High-Temperature Digital Thermometer (from SILICON CHIP's "Performance Electronics For Cars") to use on my modified car. I am trying to use it to display the coolant temperature and operate a pump and fans on an air-to-water intercooler set-up I am building. I adjusted the kit to the specifications in the instructions and it reads temperatures fine but I cannot get the relay to switch properly.

What is the minimum hysteresis of the kit, as I want it to switch everything on at 30°C and off at 20°C to keep my intake temperatures as low as practical? Would I be better off with the Adjustable Temperature Switch? Could I use it with the thermocouple input of the display in parallel? (S. G., Nowra, NSW).

- The hysteresis is about 11°C at its minimum as the thermometer was designed more as a high-temperature switch where 11°C is insignificant. You can reduce the temperature hysteresis by using a smaller value for the 220Ω resistor connected between pin 3 of IC3 and pin 6 of IC2. A 100Ω resistor should enable a 10°C hysteresis with VR5 set to less than 1MΩ.

You could use the Temperature Switch but with the above changes, the High-Temperature Digital Thermometer should work just as well.

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ESR type (16V). And the cathode of diode D1 should be connected directly to the injector's 12V supply.

If you use two Mosfets, then separate diodes (D1) and 10Ω gate drive resistors will be required. In addition, another gate protect zener diode (ZD3) should be included across the second Mosfet's gate and source terminals.

Drift problem in tank level meter

I built the full telemetry version of the PIC-Based Tank Level Meter (SILICON CHIP, November & December 2007) from a Jaycar kit and it all works very well but with a peculiar problem. All calibrations were done before installation but over the subsequent weeks the reported temperature slowly became more inaccurate (dropping) along with the battery voltage. After about six weeks, I decided the battery had died but on replacement I discovered that in fact it was fully charged (1.4V).

However, the regulated 5V bus had increased to 5.5V. It was reset but the problem persisted and after another four weeks the voltage had risen to 5.38V. I am assuming a component is changing in value but don't know which one. Any help would be appreciated. (D. S., via email).

- The voltage drift in IC1 would be either due to trimpot VR1 or the 10kΩ resistor at pin 2 varying over time or IC1 (TL499A) itself drifting with time. Most likely, it is the trimpot that is rising in resistance and a good-quality unit should fix this.

Alternatively, measure the resistance that gives a 5V output and substitute a fixed-value resistance for the trimpot (use series or parallel 1% resistors to make up a value close to that required).

Monitoring water tanks

With all the emphasis on water management these days, there is a need for a remote water level sensor on rain water tanks which will bring the level information into the kitchen. This would require an ultrasonic detector working at intervals of some preset time to conserve power in the remote unit and transmit the information to the kitchen via a wireless link.

The preset timer could be one transmission every six hours and in the event of falling rain this timer could be reduced to 1-hour intervals. With all the gadgets around today, I am sure that this is achievable and I was wondering whether a cheap PIC would do the job, one at each end including the radio transmission and receiving. I would be glad of your comments. (D. B., via email).

- We have produced a number of water tank monitors. The one most closely fitting your description was described in the November 2007-January 2008 issues and it did employ a 433MHz radio telemetry link.

Three kits were made available by Jaycar (KC5460, 61 & 62). Check with Jaycar to see if they're still available.

We can supply back issues for $12 each including GST and p&p or $A15 each including airmail and p&p outside Australia.

Robot circuit lacks full Mosfet drive

With reference to the Programmable Robot (SILICON CHIP, September 2004), I have a query about the two MPT3055V Mosfets (Q2 & Q5) that turn the motors on/off. With 5V from the PICAXE P0 output to the gates and 6V to the drain terminals, I am getting 2.7V output on the source terminals. Should this not be 5V to 6V?

To check this 2.7V, I have isolated Q2 & Q5 from the line to Q3, Q6, Q9 & Q11. The PICAXE08M has a separate 5V supply from the 6V motor battery.

My guess is that I should replace Q2 & Q5 but with the low voltages and current involved there should not be any damage unless I have shorted something. (N. A., via email).

- Mosfets Q2& Q5 will never switch on fully for the full supply to be available at the source. That's because the

Adjustment Problems With High-Temperature Thermometer

I have assembled the High Temperature Digital Thermometer kit (from SILICON CHIP's "Performance Electronics For Cars") which I obtained from Jaycar. I have assembled other kits without problems but I have run into trouble with this one.

The first thing I did was to check the polarity of all the diodes, electrolytic capacitors and ICs. I have also checked for solder bridges on the tracks and dry joints (all OK).

The next thing I did was to check a few voltages. The voltage rail which is supposed to be 4.98V (Test Point 1) cannot be adjusted below 5V and the voltage at Test Point 2 cannot be adjusted below 2.59V. I expect this to affect the accuracy of the device but in my case the reading on the LCD indicator just drifts and it does the same when its input is disconnected.

The 2.59V shows up on pin 3 of op amp IC2 which puzzles me a bit. Do you think that this and the adjustment problem could be due to a damaged cold junction compensation device and possibly the voltage regulators REF1 and REF2? I would appreciate any helpful ideas which you may have. (W. M., via email).

● REF1 and REF2 need to be able to be adjusted to 2.49V. The 2.59V possibly means a faulty diode or reference IC. Check the voltage across D2 and D3 for about 0.6V or 0.7V. VR1 should be able to vary the ADJ voltage for REF1 over a range from about 1.9V down to 0.6V with respect to TP2.

Drift on the display possibly means that the connections at the display module are incorrect with an open-circuit input. Check that Inlo is connected to the 2.49V rail, Refhi is connected to Rdh and Reflo is connected to Com.

Pin 3 of IC2 should have the 2.49V reference (approximately) with the 40.6μV/°C offset to that. IC1 is probably OK.

Mosfets need a gate voltage higher than the source to switch on. Expected source voltage would be around 3V.

If you want more voltage, Q2 & Q5 would have to be P-channel Mosfets and the sense of the P0 output would have to be inverted.

Energy Meter needs updating

Some years ago, I built the Energy Meter (SILICON CHIP, July & August 2004). It has been invaluable in determining the running costs of all my electrical appliances. The cost of a kilowatt-hour is now 26.5 cents (including extra charges). To clarify this, my last account is as follows: total kWh consumed = 2283, total cost = $604.23 = 26.47 cents/kWh. The Service Charge ($63.99) and GST ($54.93) have been added into the total cost.

The problem now is that the cost per kWh in the meter circuitry is limited to 25.5c/kWh (as programmed into the IC). No circuit designer could have imagined that the cost of electricity would increase from 16c/kWh (the maximum catered for when I first built the project) to 26.5c/kWh today.

Is it possible to change the relevant IC to a higher electricity cost of 40 cents/kWh? (D. V., via email).

● Unfortunately, the software is not easily changed since the 255 limit is actually the maximum value of an 8-bit binary number used as the cents per kWh setting. While the software could be rewritten to use a 16-bit number instead (allowing for up to $6553.60 per kWh) we are not in a position to do that at present.

As an alternative, you could set the cents/kWh value to half that of the rate and mentally double the reading.

We note that you include the standing (service supply) costs in the cents/kWh rate and that raises the overall cents per kWh rate. That is not a valid way to do it since the rate then is dependent upon usage. For example, if you did not use any electricity and the service costs are included in the c/kWh rate, then this value would need to be infinity.

The standing costs need to be added later to the cost after the usage has been costed.

48V charger for electric car

I have decided to build an electric car but I need a reliable 48V 20A charger. Is there a possibility to make some changes to your existing Battery Charge Controller for 12V lead-acid or SLA batteries (SILICON CHIP, April 2008) to charge at 48V?

The batteries are lead acid but eventually will be $LiFePYO_4$ 200Ah. I suppose there is no big difference between charging lead-acid and Li. (M. V., Valjevo, Yugoslavia).

The battery charger from April 2008 could be modified for 48V. Use a 1.8kΩ 5W resistor in place of the 100Ω resistor at switch S1 and change R1 to 24kΩ and R2 to 2kΩ. The 1.5kΩ resistor in series with LED5 should be increased to 6.2kΩ. Q1 needs to be an N-channel Mosfet rated at 80V or 100V and over 40A for the charging current you require and will need to be mounted on a suitable heatsink.

Finally, the software will need changing to suit $LiFeYPO_4$ batteries.

Simple EFI system for small motors

I like the CDI Replacement For Small Engines (SILICON CHIP, May 2008) and am going to built one for my ride-on lawnmower. How possible is it to combine this circuit with a LM1949 injector controller to make a simple EFI system for these small engines? (E. E., Bela-Bela, South Africa).

● It's not practical to utilise the CDI to activate the LM1949 injector driver directly without adding considerable extra circuitry.

First, the injector driver must be fed a pulse that sets the required injector opening period and this would need to vary with throttle opening and RPM. So a throttle circuit that allows the injector opening to vary with throttle position would be required, along with a pulse width circuit that varied with RPM.

In addition, the motor would need a 12V supply capable of delivering up to 4A to supply the injector so that the latter will open. This makes the injector drive impractical for engines that are purely magneto ignition without a 12V generator/alternator and battery.

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GPS tracker wanted for moggie

Firstly, thanks for the continued high standard of your publication. I have been an electronics enthusiast since a child in the late 1950s and I still look forward to your regular reading.

I have a young cat and we love her dearly but it roams and it is valuable. How about a small GPS tracker that could attach to her collar, transmitting the location so that we would know her whereabouts? It would have to be small and not too heavy (it's a small cat) but it seems to me to be possible with pre-built GPS modules now available. It would of course be helpful for dogs too. (J. O., via email).

● It is doubtful whether it would be viable for us to do all the work in developing such a project, especially as the likely cost of the unit may be more than equivalent commercial units. If you do a Google search you will quickly find that there are GPS trackers for cats, dogs, children and people with Alzeimers.

Picking up digital TV signals

As far as I know, when the analog TV signals get turned off, the lowest channel for DVB-T in Australia will be Channel 6 with a frequency of about 180MHz. FM radio is 88-108MHz, so why can't I buy as a stock item a passive LC crossover-type splitter, centred at about 144MHz?

I used to see a VHF/UHF version of these inside 1970s TV sets that had separate VHF and UHF tuners. (M. G., via email).

● It really depends on the antenna you have. If you have a combined VHF/UHF TV antenna then this may work. A standard VHF antenna designed for FM may be able to receive channel 6 but this is unlikely as an FM antenna is tuned to the 88-108MHz band (Band II) rather than to 174-230MHz for DVB-T channels 6-12. A UHF antenna is required for Band IV (526-582MHz) and band V (582-820MHz).

OBDII interface suggestions

It appears that the OBDII Interface/Interpreter project (SILICON CHIP, February 2010) downloads all the data from the car that's relevant for a car computer like the OzTrip Car Computer (SILICON CHIP, March 2000). As such, perhaps some suitable software is all that would be required to manipulate and display the data on a laptop screen in a car computer way.

Would you know of any software which would do the task? (F. J., via email).

● That's a good idea. **http://www.obdsoftware.net/TouchScanInfo.aspx** has OBDII software for use with the ELM327 (as used in the SILICON CHIP OBDII interpreter) and has speedo, fuel consumption, distance and tacho readouts, etc.

13.8V supply for mobile phone charger

I have a need for a power supply for a mobile phone. Input would be 240VAC, say one metre flex with a 3-pin plug which goes into a plastic box containing suitable electronics to provide 12V or 13.8V DC to a cigarette lighter socket mounted on the other side of the plastic box.

I can then use this power supply, with a car charger lead when I leave my

continued on page 104

Headlight Reminder Beeps Continuously

I purchased the Headlight Reminder kit (SILICON CHIP, August 1999) and assembled it but am having problems. At first, I did not include the door switch, so the unit beeps when I start the car and will beep continuously for about 20s after I have turned the ignition and lights off. The unit also beeps as above even if the lights are not on.

I then connected the door switch and now have the same problem every time I open the door (after first switching off the ignition). If I close the door while it is beeping (say after 10s) and then re-open the door it will continue beeping for another 10s until the 20s is finished.

I have connected it correctly as the door and lights are at zero voltage when open/on. Please advise what I need to do. (W. H., via email).

● The problem may be due to the way the links are connected. You need to have a jumper in LK1 or LK2 and a jumper in LK3, LK4 or LK5. This is so that an input will not be floating.

Also make sure the links are connected according to the table on the circuit. If these are connected correctly, perhaps there is a bad solder joint on the PCB or the resistor values are incorrect.

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. . . continued from p101

240VAC charger at work or misplace it.

Obviously a unit like this could be used with any mobile phone as the car charger lead is the only special component needed, which every mobile phone user probably already has. A plugpack type unit like this is available in England. Car cigarette lighter sockets are only " live " with the key in the ignition in the accessories position which I don't like to do. (B. G., via email).

● That seems like an odd request. After all, 240VAC phone chargers are very cheap and compact. Why go to the bother of making a dedicated 13.8V supply with a cigarette socket just so you can plug in your DC charger?

LED problem in Remote Control Extender

I purchased the kit for the Infrared Remote Controller (SILICON CHIP, June 2006) from Jaycar Electronics. I appreciate that their warranty only extends to parts but having carefully assembled it, the circuit does not work and I conclude that either a component has failed or the design is faulty.

I have powered the circuit with 9V DC. The voltage across is ZD1 is about 5.1V. The acknowledge LED does not flash when an IR remote control is used. I have tried it with Samsung, Panasonic and Sky Remotes but to no avail. It looks to me that the input sensing circuit is not working.

I would appreciate your advice as to how I should proceed. (D. S., via email).

● It is likely that LED1 has been installed with incorrect polarity. The flat of the LED should not be facing IC1.

In order for the circuit to work, trimpot VR1 must be adjusted for the correct carrier frequency as described in the testing section. In addition, the IRLED (LED2) must be wired to CON1 with the correct polarity. SC

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Notes & Errata

Induction Motor Centrifugal Switch Over-ride, Circuit Notebook, September 2012: there is an error with this circuit. When changing motor speeds, the run LED (in the controller) flickers and in some cases retriggers the 555 (IC1). To fix this, the 10nF capacitor across the 10MΩ resistor should be changed to a 4.7µF electrolytic and connected via a 1N4148 series diode to pin 10 of the PIC (anode to pin 10). The positive side of the electrolytic goes to the cathode.

Also when using this circuit, it is best not to set the motor speed below about 25% as the LED can go out completely and retrigger the 555.

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